THE EPA RENEWABLE FUEL STANDARD MANDATE

JOINT HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY &
SUBCOMMITTEE ON OVERSIGHT

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTEENTH CONGRESS

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July 23, 2015

THE EPA RENEWABLE FUEL STANDARD MANDATE

THURSDAY, JULY 23, 2015

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY &
SUBCOMMITTEE ON OVERSIGHT,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittees met, pursuant to call, at 10:05 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Randy Weber [Chairman of the Subcommittee on Energy] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

Congress of the United States
House of Representatives

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Subcommittees on Energy and Oversight

The EPA Renewable Fuel Standard Mandate

Thursday, July 23, 2015
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Witnesses

Mr. Matthew Smorch, Vice President for Strategy and Supply, CountryMark

Dr. Jason Hill, Associate Professor of Bioproducts and Biosystems Engineering, University of Minnesota

Mr. Chuck Red, Vice President of Fuels Development, Applied Research Associates, Inc.

Mr. Tim Reid, Director of Engine Design, Mercury Marine

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HEARING CHARTER

The EPA Renewable Fuel Standard Mandate

Thursday, July 23, 2015
10:00 a.m. – 11:30 a.m.
2318 Rayburn House Office Building

PURPOSE

The Subcommittees on Energy and Oversight will hold a joint hearing titled *The EPA Renewable Fuel Standard Mandate* on Thursday, July 23, 2015, starting at 10:00 a.m. in Room 2318 Rayburn House Office Building. The purpose of this hearing is to discuss the vast change in technical and market conditions in today's energy sector compared to when the Renewable Fuel Standard (RFS) was established in legislation enacted in 2005 and 2007. The hearing will discuss the cost and environmental impact of the RFS mandate. The hearing will also discuss the technical challenges involved for a variety of engines and transportation fuel distribution systems as more biofuels are blended in the transportation fuel supply.

WITNESS LIST

- **Mr. Matt Smorch**, Vice President for Strategy and Supply, CountryMark
- **Dr. Jason Hill**, Associate Professor of Bioproducts and Biosystems Engineering, University of Minnesota
- **Mr. Chuck Red,** Vice President of Fuels Development for Applied Research Associates, Inc
- **Mr. Tim Reid,** Director of Engine Design, Mercury Marine

BACKGROUND

The Renewable Fuel Standard (RFS) was established in the Energy Policy Act of 2005 (EPACT 05), which required transportation fuels in the continental U.S. contain, or be blended with, renewable biofuels at increasing volumes.[1] When the RFS was initially designed, the primary goals were to reduce greenhouse gas emissions, reduce crude oil imports, and accelerate the use of a variety of renewable fuels by blending biofuels into the U.S. transportation fuel supply.[2]

In 2007, the Energy Independence and Security Act of 2007 (EISA) expanded the scope of the RFS (commonly known as RFS2) by mandating the blending of 20.5 billion gallons of biofuels

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[1] P.L. 109-58, Energy Policy Act of 2005. Aug. 8, 2005. Available at http://www.gpo.gov/fdsys/pkg/PLAW-109publ58/pdf/PLAW-109publ58.pdf

[2] Environmental Protection Agency, Renewable and Alternative Fuels. Available at http://www.epa.gov/otaq/fuels/alternative-renewablefuels/index.htm

into U.S. transportation fuels by 2015, and 36 billion gallons by 2022.[3] EISA established four specific categories of renewable fuel—conventional biofuels, advanced biofuels, cellulosic biofuels, and biomass-based diesels, with specific target requirements for each category of fuel outlined in the law. The conventional biofuels category is primarily made up of fuels from corn ethanol. .[4]

Advanced biofuels are biofuels produced from feedstocks other than cornstarch that achieve lifecycle greenhouse gas emissions of 50% lower than petroleum fuels, while cellulosic biofuels are required to reduce lifecycle greenhouse gas emissions by 60%.[5]

Under EISA, the EPA has waiver authority to reduce volumes of renewable fuels below the volumes specified in the statute under certain circumstances, including annual production rate of renewable fuels, impact on energy security and the environment, as well as other factors such as job creation, price and supply of agricultural commodities, rural development and food prices.[6] The EPA has consistently used this waiver authority, lowering the cellulosic biofuel mandate from 2010 to 2013, and proposing to do so again for all renewable fuel volumes in 2014-2016.[7]

RFS Compliance

The EPA manages compliance with the RFS through a fuel credit system incorporating Renewable Identification Credits (RINs).[8] RINs are generated with each qualifying gallon of renewable fuels produced by biofuel producers and importers, and can be traded and sold like other commodities. In order to comply with biofuel volumes mandated under the RFS, petroleum refiners and importers within the continental U.S. and Hawaii must acquire RINs to meet their renewable volume obligation (RVO), and submit these RINs to the EPA to show compliance with annual RFS requirements.[9]

[3] P.L. 110-140, Energy Independence and Security Act of 2007. Dec. 19, 2007. Available at http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf

[4] Environmental Protection Agency, *Renewable Fuel Standard (RFS)*. Available at http://www.epa.gov/OMSWWW/fuels/renewablefuels/index.htm

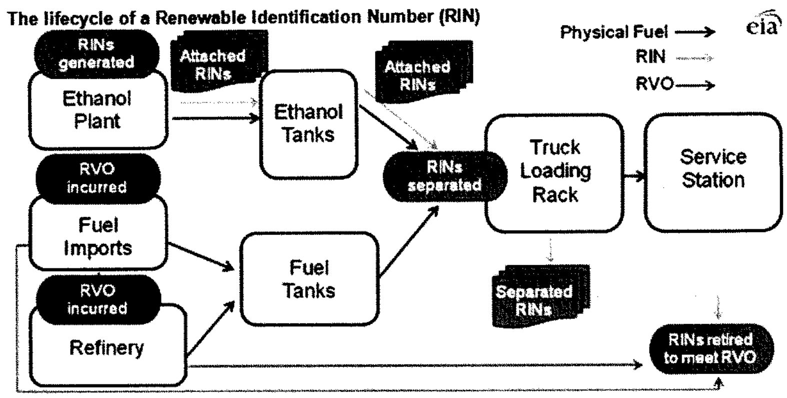
[5] Congressional Research Service. *Calculation of Lifecycle Greenhouse Gas Emissions for the Renewable Fuel Standard (RFS)*. March 12, 2010. Available at http://nationalaglawcenter.org/wp-content/uploads/assets/crs/R43325.pdf

[6] P.L. 110-140, Energy Independence and Security Act of 2007. Dec. 19, 2007. Available at http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf

[7] Congressional Research Service, *The Renewable Fuel Standard (RFS): In Brief*, June 29, 2015. Available at http://nationalaglawcenter.org/wp-content/uploads/assets/crs/R43325.pdf

[8] Congressional Research Service, *The Renewable Fuel Standard (RFS): In Brief*, June 29, 2015. Available at http://nationalaglawcenter.org/wp-content/uploads/assets/crs/R43325.pdf

[9] Ibid.



[10]

The EPA sets the annual RVO by translating the biofuels volumes required in statute into a percentage of the total transportation fuel (gasoline and diesel) sold within the U.S. The EPA estimates the total volume of the annual transportation fuel supply to determine this percentage, issues a proposed rule, and is required to promulgate an annual standard by November 30th each year to provide percentages to industry. Accordingly, each individual refiner's RVO is determined by the total gasoline and diesel fuel they produce for sale multiplied by the annual renewable fuel percentage standards mandated by EPA.[11] This formula allows refiners to determine the number of RINs the refiner is responsible for submitting to EPA to prove compliance with the RFS.[12]

To date, the majority of annual volumes required under the RFS have been met with corn ethanol biofuels, largely through the sale of E10, or ten percent blended gasoline. However, as the RFS volumes continue to increase over time, the share of mandated volumes for advanced and cellulosic biofuels grows, with cellulosic biofuels requirements increasing from less than 1% of required volumes in 2010 to 44% of the required volumes in 2022.[13]

Challenges

The RFS creates a number of challenges for refiners, biofuel producers, engine manufacturers, and distributors of the U.S. transportation fuel supply—eventually impacting the American consumer through the price and availability of fuels. These issues include ongoing uncertainty in EPA management of the RFS, difficulty in achieving adequate levels of renewable fuel production, and the impact of "blend wall" on meeting RFS volume requirements in the future.

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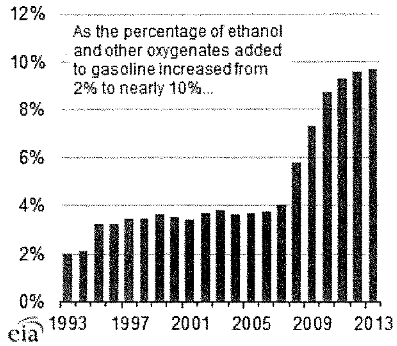
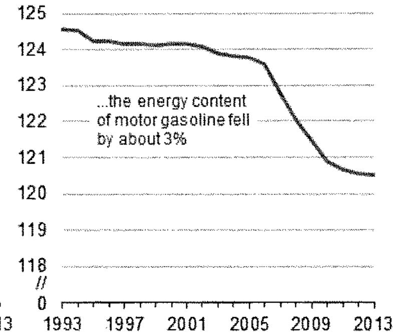
[10] Energy Information Administration, *RINs and RVOs are used to implement the Renewable Fuel Standard*. June 3, 2013. Available at http://www.eia.gov/todayinenergy/detail.cfm?id=11511
[11] Ibid.
[12] Energy Information Administration, *RINs and RVOs are used to implement the Renewable Fuel Standard*. June 3, 2013. Available at http://www.eia.gov/todayinenergy/detail.cfm?id=11511
[13] P.L. 110-140, Energy Independence and Security Act of 2007. Dec. 19, 2007. Available at http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf

Reductions in the energy content and efficiency of transportation fuels due to increased blending of biofuels also lower customer demand for mid-level ethanol blend fuels.[14]

Oxygenate content of gasoline (1993-2013)
percent by volume



Energy content of motor gasoline (1993-2013)
thousand Btu per gallon



[15]

Uncertainty and Demand

The EPA finally released a proposed standard to implement the RFS for 2014-16 on May 29, 2015, after almost an 18 month delay for the 2014 standard. This delay created uncertainty for both conventional and renewable fuel producers. In 2014, EPA announced it would not finalize a rule at all during the calendar year, and would instead postpone the updated standard from 2014 until 2015.[16] The EPA's decision to ignore statutory requirements created long-term uncertainty that could threaten adequate supply for meeting volume requirements for renewable fuels in the future.

Demand and consumption rates also present challenges to the RFS. EISA projected significantly higher demand for gasoline than has occurred, and assumed technological advances in cellulosic and advanced biofuels production to meet increasing volume requirements.[17] As statutory mandates increase and demand declines based on projections, higher percentages of biofuels are required to be blended into the fuel supply to meet the RFS requirements. In the proposed RFS rule for 2014-2016, the EPA recognized that "limitations in the ability of the industry to produce sufficient volumes of qualifying renewable fuel, particularly non-ethanol fuels" was a significant limiting factor in meeting the volume requirements outlined in statute.[18] In addition, limits on

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[14] Energy Information Administration, *Increasing ethanol use has reduced the average energy content of retail motor gasoline*, October 27, 2014. Available at http://www.eia.gov/todayinenergy/detail.cfm?id=18551
[15] Ibid.
[16] Bloomberg, *EPA Won't Finalize Renewable Fuel Standard in 2014, Cites Lengthy Delays*, November 24, 2014. Available at http://www.bna.com/epa-wont-finalize-n17179912489/
[17] Environmental Protection Agency, *EPA Proposes Renewable Fuel Standards for 2014, 2015, and 2016, and the Biomass-Based Diesel Volume for 2017*, May 2015. Available at http://www.epa.gov/OMSWWW/fuels/renewablefuels/documents/420f15028.pdf
[18] Ibid.

the amount of ethanol that can be blended, also known as the "blend wall" offer a significant challenge to meeting future requirements.

The Blend Wall

The "blend wall", or ten percent ethanol, is considered the upper limit to the total amount of ethanol that can be blended into U.S. transportation fuel supply while still maintaining engine performance and compliance with the Clean Air Act.[19] The blend wall is considered a significant challenge to meeting future biofuel volumes mandated in the RFS, and is in conflict with the biofuel volumes mandated in the RFS. The EPA specifically acknowledged the blend wall in the proposed rule issued last May, and recognized that "limitations in the volume of ethanol that can be consumed given practical constraints on the supply of higher ethanol blends to the vehicles that can use them" was a primary factor in EPA's decision to exercise its waiver authority.[20]

Due to the blend wall, which places a physical limit on blending that is less than is mandated in statute, RFS volumes that exceed approximately 13.3 billion-gallons/year cannot be met by incorporating more E10 into the transportation fuel supply.[21] In an effort to avoid the blend wall, Growth Energy and 54 ethanol manufacturers petitioned the EPA in 2009 to allow E15, a mid-level or intermediate ethanol blend, into the commercial marketplace.[22]

E15

Under the Clean Air Act, the EPA is prohibited from introducing a new fuel unless it is "substantially similar" to gasoline, but is authorized to grant a waiver of this prohibition. In response to the Growth Energy petition, the EPA issued a partial waiver for E15 in October 2010, to allow the introduction of E15 into the commercial marketplace for use in model year 2007 and newer cars, light-duty trucks, and SUVs.[23] In January 2011, EPA granted another partial waiver for use of E15 in model year 2001 and newer vehicles.

The EPA did not grant a waiver for the use of E15 fuel in model years prior to 2001. Nor is E15 approved for use in motorcycles, vehicles with heavy-duty engines, off-road vehicles (such as boats and snowmobiles), engines in off-road equipment (such as lawnmowers and chain saws),

[19] Congressional Research Service, *The Renewable Fuel Standard (RFS): In Brief*, June 29, 2015. Available at http://www.crs.gov/pdfloader/R43325.
[20] Environmental Protection Agency, *EPA Proposes Renewable Fuel Standards for 2014, 2015, and 2016, and the Biomass-Based Diesel Volume for 2017*, May 2015. Available at http://www.epa.gov/OMSWWW/fuels/renewablefuels/documents/420f15028.pdf
[21] Tyner, Wallace. *Biofuel Economics and Policy: The Renewable Fuel Standard, the Blend Wall, and Future Uncertainties* Purdue University, West Lafayette, IN, USA. Available at https://www.safaribooksonline.com/library/view/bioenergy/9780124079090/XHTML/B9780124079090000304/B9780124079090000304.xhtml
[22] Environmental Protection Agency, *E15 (a blend of gasoline and ethanol)*. Available at http://www.epa.gov/otaq/regs/fuels/additive/e15/index.htm
[23] Ibid.

cars manufactured in the year 2000 or earlier, light-duty trucks, and medium-duty passenger vehicles.[24] These limitations on the practical use of E15 reduce its demand and broader use.

E85

E85 is a blend of 85 percent ethanol and 15 percent gasoline.[25] E85 is heavily restricted and is only available for use in Flex Fuel Vehicles (FFVs) that are specifically designed to run on E85, gasoline, or a blend of both fuels.[26] E85 cannot be used in gasoline-only, conventional engines of any kind. E85 also has limited availability nationwide, due to low demand and minimal distribution infrastructure.

However, much like E15, due to limitations in use that lowers demand, E85 does not currently offer a reasonable pathway to overcome the limitations of the blend wall.

Important questions and key issues to be discussed at the hearing include:

- What impact do the technical restrictions for the use of mid-level ethanol blends have on the overall feasibility of meeting the volume targets mandated in the RFS? How do these technical limitations reflect on the demand for E15 and E85?

- Is the U.S. transportation fuel market capable of absorbing higher volumes of E85 and E15 to meet future RFS requirements? What impact could those higher volumes have on consumer pricing?

- What is the environmental impact of increased use of biofuels, including the lifecycle emissions and impact on air quality? How do the lifecycle emissions of corn ethanol and cellulosic ethanol compare to gasoline?

- What is the impact of mid-level ethanol blends on small engine performance? What are the concerns for human safety, environmental impact, and technology associated with ethanol blends over 10 percent use in small engines?

- What additional research is necessary to determine the impact of mid-level ethanol blends on durability, emissions, and operations of various types of engines?

[24] Ibid.
[25] Environmental Protection Agency, *E85 and Flex Fuel Vehicles*, May 2010. Available at http://www.epa.gov/otaq/fuels/renewablefuels/documents/420f10010a.pdf
[26] Ibid.

Chairman WEBER. The Subcommittee on Energy and Oversight will come to order.

Without objection, the Chair is authorized to declare recesses of the Subcommittee at any time.

Welcome to today's hearing titled "The EPA Renewable Fuel Standard Mandate." I recognize myself for five minutes for an opening statement.

Good morning, and welcome. This is a Joint Energy and Oversight Subcommittee hearing examining the Renewable Fuel Standard, or RFS. Today, we're going to hear from witnesses with direct experience navigating this complex and outdated mandate. The RFS was designed to increase the use of renewable sources of transportation fuels in order to reduce United States reliance on foreign oil and also reduce vehicle emissions. But Congress, when it enacted this mandate, based it on overly ambitious projections about gas consumption, availability of renewable fuel vehicles and infrastructure, biorefinery technology, and even the market demand for renewable fuels. In almost every category the RFS projections are outdated and do not reflect today's energy market.

The RFS was wrong about gas consumption. Demand for gasoline is actually falling. The RFS was wrong about the growth of the renewable fuel industry, particularly in terms of advanced biofuels and cellulosic fuels. And the RFS was wrong about the impact incorporating renewable fuels would actually have on the environment. As one of our witnesses today will testify, the corn ethanol produced to meet the RFS actually makes air quality worse and has higher lifecycle emissions than gasoline.

Today, instead of a transportation fuel supply driven by consumer demand, we are stuck with our back—pardon the pun—to the blendwall. Each year, the RFS requires higher volumes of renewable fuel than our transportation fuel supply can sustain. Even with EPA approval to use midlevel ethanol blends like E15 and E85 in select vehicles, both, I might add, of which have significant problems in terms of performance and emissions, the RFS mandate is still unworkable. This leaves refiners at the mercy of unreliable annual waivers from the EPA that set the standard at achievable levels, when EPA even bothers to follow the law and announce those requirements on time. And American consumers are stuck with higher prices and less options at the pump.

The RFS shows that the federal government cannot use mandates to create a functional industry out of thin air. Production of renewable fuels has increased, but demand for fuels with higher blends of ethanol simply does not exist, even in the most favorable market conditions. While the federal government has an important role in energy research and development, including developing efficient transportation fuel technologies, federal mandates are the wrong approach to fueling innovation, and let me add, the wrong approach to innovating fueling, and pardon that pun.

I want to thank our witnesses today for testifying on the challenges of the RFS in today's energy market, and I look forward to a discussion about the consequences caused by the federal government's intervention in the American energy market. In the case of the RFS, like so many other instances of federal government mandates, the results are disastrous. Congress has the opportunity to fix the problems caused by this outdated and misinformed law, and should advance legislation to repeal the RFS. We can't afford to hijack economic growth by continuing with a law that is at odds with reality, and will raise costs for American consumers.

[The prepared statement of Chairman Weber follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON ENERGY
CHAIRMAN RANDY K. WEBER

Good morning and welcome to today's Joint Energy and Oversight Subcommittee hearing examining the Renewable Fuel Standard, or RFS. Today, we will hear from witnesses with direct experience navigating this complex and outdated mandate.

The RFS was designed to increase the use of renewable sources of transportation fuels in order to reduce U.S. reliance on foreign oil and reduce vehicle emissions.

But Congress, when it enacted this mandate, based it on overly ambitious projections about gas consumption, availability of renewable fuel vehicles and infrastructure, bio-refinery technology, and the market demand for renewable fuels. In almost every category, the RFS projections are outdated and do not reflect today's energy market.

The RFS was wrong about gas consumption—demand for gasoline is falling. The RFS was wrong about the growth of the renewable fuel industry, particularly in terms of advanced biofuels and cellulosic fuels. And the RFS was wrong about the impact incorporating renewable fuels would have on the environment. As one of our witnesses today will testify, the corn ethanol produced to meet the RFS makes air quality worse, and has higher life cycle emissions than gasoline.

Today, instead of a transportation fuel supply driven by consumer demand, we are stuck with our back to the "blend wall." Each year, the RFS requires higher volumes of renewable fuel than our transportation fuel supply can sustain. Even with EPA approval to use mid-level ethanol blends like E15 and E85 in select vehicles—both of which have significant problems in terms of performance and emissions—the RFS mandate is unworkable.

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Congress has the opportunity to fix the problems caused by this outdated and misinformed law, and should advance legislation to repeal the RFS. We can't afford to high-jack economic growth by continuing with a law that is at odds with reality, and will raise costs for American consumers.

Chairman WEBER. And I'd like to recognize Mr. Grayson for his statement.

Mr. GRAYSON. Thank you, Chairman Weber and Chairman Loudermilk, for holding this hearing today.

Currently, the United States consumes more oil than any other nation in the world: 18.9 million barrels per day. China is next at only 10.8 million barrels per day. The sheer volume of America's oil consumption means that we are constantly spurring global climate change and disruption and its disastrous consequences. Further, our oil consumption leaves America heavily dependent on the global market for oil, and this reliance makes our economy vulnerable. Any significant supply disruption can have catastrophic effects on our economy.

These concerns, however, can begin to be addressed by the sustainable use of biofuels and long-term policies like the Renewable Fuel Standard, which is what we are here to talk about today. This policy, signed into law twice under President George W. Bush, requires an increase in the production of biofuels that can be introduced into the market. The Renewable Fuel Standard has resulted in greater production of alternative fuels, and has created a burgeoning market for them. Breakthrough technologies have emerged, as have innovations and new infrastructure that are changing the biofuels landscape every day.

As we will hear from Dr. Hill, over the long term we need to move away from corn-based ethanol due to its supply limitations. In the short term, we need to ensure that efficient, sustainable practices for producing corn-based ethanol are sufficiently incentivized and enforced. We must also ensure that the market for these first-generation fuels is establishing the necessary infrastructure and investments that will lead to truly sustainable advanced biofuels. The expansion of the Renewable Fuel Standard in 2007 was designed to do just that by increasing levels of advanced biofuels through annual volumetric requirements, requirements that I hope that industry and the EPA can come to agreement on so that EPA can begin announcing annually once more.

I look forward to hearing from each of you, our witnesses on today's panel, and I want to thank you for being here. In particular though, I'd like to thank Mr. Red for testifying. As you will hear, Mr. Red is the Vice President of Fuels Development at Applied Research Associates in Panama City, Florida. His company is working on breakthrough products that can be used as drop-in advanced biofuels to replace diesel and jet fuel. He will note that these types of innovations wouldn't have been possible without the Renewable Fuel Standard, which I believe is an important perspective for all of us to hear today.

While they may not be the sole solution to the glaring problem of climate disruption, biofuels, especially advanced biofuels, are a step in the right direction. Without the Renewable Fuel Standard, we would not even be here discussing the significant progress made in biofuels over the past decade.

I look forward to what the next decade of biofuels holds in store, and again, I look forward to hearing from each one of you this morning.

Thank you, Mr. Chairman. I yield back.

[The prepared statement of Mr. Grayson follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON ENERGY
MINORITY RANKING MEMBER ALAN GRAYSON

Thank you, Chairman Weber, and Chairman Loudermilk, for holding this hearing today.

Currently, The United States consumes more oil than any other nation in the world— 18.9 million barrels per day. China is the next closest at 10.8 million barrels per day.

The sheer volume of America's oil use means we are constantly furthering global climate change and its disastrous effects. Further, our oil consumption leads America to be heavily dependent on the global market for oil, and this reliance makes our economy vulnerable. Any significant supply disruption has the potential to be a catastrophic economic event.

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Chairman WEBER. Thank you, Mr. Grayson.

I now recognize the Chairman of the Subcommittee on Oversight, Mr. Loudermilk, for his opening statement.

Mr. LOUDERMILK. Thank you, Mr. Chairman, and good morning to everyone. I would also like to welcome and thank all of our witnesses for being here today.

The Renewable Fuel Standard was established in 2005 with the signing of the Energy Policy Act, and expanded significantly the Energy Independence and Security Act of 2007. At that time, gasoline consumption was on the rise, America's reliance on foreign oil was increasing, and renewable fuels were just starting to become an option for consumers. In drafting the Renewable Fuel Standard, Congress projected that gas prices and consumption would increase, and established increasing requirements for incorporating renewable fuels into the transportation fuel supply.

But today's energy market is remarkably different than what Congress projected in the Renewable Fuel Standard. Gas consumption has declined, and technology has opened the door for an abundance of domestic oil and gas. While production of renewable fuels has increased, and blended fuels are more widely available to consumers, the refining capacity and market demand for transportation biofuels projected in the RFS simply does not exist. Instead of a large increase in in renewable fuel production to match RFS targets, refiners must navigate a complex fuel credit system, buying or trading for Renewable Identification Credits, or RINs, to show that enough biofuels have been produced to meet RFS requirements. Since biofuels aren't produced at adequate levels, the EPA must continually waive the production volumes required in the law, causing uncertainty for producers and consumers.

As fuels with higher blends of ethanol like E15 and E85 are introduced into the fuel supply in order to meet the RFS mandate, the law can even cause confusion for consumers. While fuels with ethanol content higher than ten percent are approved for use in newer vehicle models, midlevel ethanol blends can damage small engines, like lawn mowers, boats and motorcycles, and are not approved for these uses by the EPA. Adding fuels with higher blends of ethanol to more gas stations around the country may help meet the RFS requirements, but it offers nothing more than a nuisance to regular Americans, as more gas stations have to sell fuels that they can't even use. And consumers with vehicles that are compatible with E15 often choose lower blends of ethanol, or fuel without any biofuels, due to the lower performance of fuels with a higher percentage of biofuels.

Simply put, the RFS mandates the sale of fuels with low demand. The federal government has no business mandating the sales of fuels that many Americans don't want to buy. And while the EPA projected significant environmental benefits from an increased use of biofuels, the fuel efficiency and lifecycle emissions for biofuels are in direct contrast to EPA's projections. So the American people are stuck with a law mandating less-efficient fuels that are more damaging to air quality than gasoline. It's time for Congress to make a change. When existing law is unworkable, Congress must listen to stakeholders, and adjust the law as it is needed.

Our hearing today will examine some of the challenges to complying with the RFS in today's market. As economic conditions change, Congress must evaluate the laws it creates and adjust mandates to reality. I hope that this hearing will bring to light some of the unintended consequences of the Renewable Fuel Standard, and provide guidance to lawmakers as we decide the future of this law.

With that, Mr. Chairman, I yield back the balance of my time.

[The prepared statement of Mr. Loudermilk follows:]

PREPARED STATEMENT OF OVERSIGHT SUBCOMMITTEE CHAIRMAN BARRY LOUDERMILK

Good morning everyone. I would also like to welcome and thank all of our witnesses for being here today.

The Renewable Fuel Standard (RFS) was established in 2005, with the signing of the Energy Policy Act, and expanded significantly in the Energy Independence and Security Act of 2007. At that time, gasoline consumption was on the rise, America's reliance on foreign oil was increasing, and renewable fuels were just starting to become an option for consumers. In drafting the RFS, Congress projected that gas prices and consumption would increase, and established increasing requirements for incorporating renewable fuels into the transportation fuel supply.

But today's energy market is remarkably different than what Congress projected in the RFS. Gas consumption has declined, and technology has opened the door to an abundance of domestic oil and gas. While production of renewable fuels has increased, and blended fuels are more widely available to consumers, the refining capacity and market demand for transportation biofuels projected in the RFS simply does not exist. Instead of a large increase in renewable fuel production to match RFS targets, refiners must navigate a complex fuel credit system, buying or trading for Renewable Identification Credits or RINs to show that enough biofuels have been produced to meet RFS requirements. Since biofuels aren't produced at adequate levels, the EPA must continually waive the production volumes required in the law, causing uncertainty for producers and consumers.

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And while the EPA projected significant environmental benefits from an increased use of biofuels, the fuel efficiency and lifecycle emissions for biofuels are in direct contrast to EPA's projections. So the American people are stuck with a law mandating less-efficient fuels that are more damaging to air quality than gasoline.

It's time for Congress to make a change. When existing law is unworkable, Congress must listen to stakeholders, and adjust the law as it is needed. Our hearing today will examine some of the challenges to complying with the RFS in today's market. As economic conditions change, Congress must evaluate the laws it creates and adjust mandates to reality. I hope that this hearing will bring to light some of the unintended consequences of the RFS, and provide guidance to lawmakers as we decide the future of this law.

Chairman WEBER. Thank you, Mr. Loudermilk.

And let me introduce our witnesses. Our first witness today is Mr. Matthew Storch. Is it Storch? Smorch? Okay. Well, we've got a typo here. Obviously this printer was fueled by biofuels. Did I say that out loud? Vice President of Strategy and Supply for CountryMark, and Mr. Smorch received his bachelor's degree in Chemical Engineering from Michigan Technological University and is a graduate of the Hoosier Fellows Program at Indiana University's Tobias Center for Leadership Excellence. Welcome, Mr. Smorch.

Our next witness is Dr. Jason Hill, Associate Professor of Bioproducts and Biosystems Engineering at the University of Minnesota. Dr. Hill received his bachelor's degree in biology from Harvard and his Ph.D. in Plant Biological Sciences from the University of Minnesota. Welcome, Doctor.

Our next witness is Mr. Chuck Red, Vice President of Fuels Development of Applied Research Associates. By the way, was he in your district?

Mr. GRAYSON. No, but he is a Floridian so he'll be voting for me next year.

Chairman WEBER. Okay. All right.

Mr. Red received his bachelor's degree in Electrical Engineering from the United States Naval Academy and his master's degree in business management from Troy University. Welcome, Mr. Red. And he has a Texas connection, I might add.

Our final witness today is Mr. Tim Reid, Director of Engine Design for Mercury Marine. Mr. Reid received his bachelor's degree in Mechanical Engineering from University of Iowa and his master's degree in Mechanical Engineering from University of Wisconsin. Welcome, Mr. Reid.

I now recognize Mr. Smorch for five minutes to present his testimony.

TESTIMONY OF MR. MATT SMORCH, VICE PRESIDENT FOR STRATEGY AND SUPPLY, COUNTRYMARK

Mr. SMORCH. Chairmen, Ranking Members, and Members of the Subcommittee, thank you for giving me the opportunity to testify in today's hearing on Renewable Fuel Standard. I'm Matt Smorch, and I serve as Vice President of Supply and Strategy for CountryMark Cooperative.

CountryMark is the only farmer-owned integrated oil company in the United States. The CountryMark refinery uses 100 percent American crude oil sourced from the Illinois Basin. Even though we're a small-business refiner, we have a large impact on the State of Indiana where we supply over 65 percent of the agricultural market and 50 percent the school districts in the state. Over 130,000 farmers in Indiana, Michigan, Illinois and Ohio participate in local cooperatives through which they benefit from ownership in CountryMark. As a supply cooperative, CountryMark's mission is to provide those quality products that our members require for their independent fuel and lubricants businesses to be successful.

CountryMark started using renewable fuels long before we were required to do so by the RFS. Being a small refiner, CountryMark did not become an obligated party until January of 2011. Regardless, we started blending biodiesel in 2006, and in 2008, we started blending ten percent ethanol in our gasoline. We recognize that there is a place for ethanol in the gasoline pool.

My testimony focuses on the challenges we have with increasing RFS mandates over E10. We believe the E10 blendwall is real. The E10 blendwall was created by the physical properties of ethanol and the one-pound vapor pressure waiver provided by the Clean Air Act. This waiver is not available for higher ethanol blends, which make them uneconomical to produce.

An important assumption in the EPA proposal for 2016 is an increase in E85 demand and a decreased demand of E0. To meet EPA's levels would require E85 sales to increase between 31 percent and 684 percent, plus these EPA increases have to materialize in less than 6 months. Even with Indiana's passenger fleet having 20 percent flex fuel vehicles and 15 percent of CountryMark-branded stations selling E85, CountryMark's experience shows E85 is not the answer.

The majority of our gasoline sales are E10, and if you could show the first slide?

[Slide.]

This is figure 2 from my written testimony, and it shows the percentage of CountryMark's total gasoline sales for both E85, which is in the blue, and E0 in the red. It can be seen that our sales of gasoline without ethanol, the E0, makes up a higher percentage of our total gasoline sales than E85. We sell six and a half times more E0 than E85. When seasonally adjusted, E0 sales are increasing and E85 sales are decreasing. In fact, one of our members recently converted E85 pumps to E0 service at two locations. Can you show the next slide, please?

[Slide.]

Figure 3 from my written testimony shows an expanded analysis that we did to compare E10 sales, which are in the red columns, to E85 sales in the blue columns, for retail stations that sell both products side by side. This sample of stations clearly show that when customers have the option to purchase either E10 or E85, E10 is the preference. On average, E85 sales only comprise 3–1/2 percent of total station gasoline sales.

With Indiana's infrastructure, we would expect the percentage of E85 sales would be greater. In 2014, CountryMark sold a little over a million gallons of E85, which is only 2.7 percent of the amount that we would have expected if customers were fairly purchasing E85.

Even today, with selling a million gallons of E85 a year and blending ten percent ethanol in the majority of our gasoline and almost two percent biodiesel in all our diesel fuels, CountryMark cannot blend enough renewable fuels to meet our annual obligation under the RFS. We are a net buyer of renewable fuel credits, and for 2015, we project those costs to be over $4 million.

CountryMark will continue to blend ethanol and biodiesel. We don't support repeal of the RFS because it is now woven into the fabric of rural America, where we operate. However, CountryMark supports an RFS, or an amount of ethanol that market realities support, which is E10. When mandates and market realities conflict, the market realities should win. Our experience shows E85 sales on a downward trajectory so we will continue to face a difficult road in meeting the RFS. Our only compliance option will be to purchase credits on the market for our shortfall, which in turn will increase our operating costs, putting both CountryMark and our farmer owners' investment at risk.

Thank you.

[The prepared statement of Mr. Smorch follows:]

CountryMark.

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WRITTEN STATEMENT OF

COUNTRYMARK COOPERATIVE HOLDING CORPORATION

AS SUBMITTED TO THE

SUBCOMMITTEE ON ENERGY AND THE SUBCOMMITTEE ON OVERSIGHT

Committee on Science, Space, and Technology
United States House of Representatives

On

Renewable Fuels Standard

THURSDAY, July 23, 2015

10:00 AM

Rayburn 2318

I. Introduction

Chairmen Weber and Loudermilk, Ranking Members Grayson and Beyer, and Members of the Subcommittees, thank you for giving me the opportunity to testify in today's hearing on the Renewable Fuels Standard (RFS). I'm Matt Smorch, and I serve as Vice President of Supply & Strategy for Countrymark Cooperative. As the EPA continues to develop and promulgate regulations regarding the Renewable Fuels Standard Program, I believe it is important for Congress to understand the nature of assumptions underpinning their efforts and how this process will impact and affect companies such as CountryMark.

CountryMark is the only farmer-owned integrated oil company in the United States and is recognized nationwide as a leader in the distribution of biodiesel and ethanol. The CountryMark refinery uses 100% American crude oil sourced from the Illinois Basin located in Illinois, southwest Indiana, and western Kentucky. Our refinery processes 28,000 barrels of crude per day, which represents only 0.15% of the entire domestic refining industry. Our capacity is 1/10 the size of the average refinery in our region. Even though CountryMark is small from an industry perspective, we have a large impact on the State of Indiana. CountryMark supplies over 65% of agricultural market fuels and 50% of school district fuels in the state.

CountryMark is a Small Business Refiner, and along with most other small business refiners, we are located in rural America. We, therefore, have our strongest economic impact in the rural communities we serve. In 2014, we purchased over $750 million of crude oil from the Illinois Basin. These purchases provide income to the 40,000 royalty owners in the Illinois Basin. Our products are sold and distributed through our branded dealer network, providing solid employment throughout the rural communities of Indiana, and many of the surrounding states.

CountryMark's operations employ nearly 500 workers, mostly in the rural economy of southwest Indiana and southeast Illinois. In Posey County, Indiana alone, a county with only 26,000 residents, over $30 million in wages and benefits are provided each year. CountryMark consistently ranks as one of the top three employers in Posey County.

As a result of companies like CountryMark, the Illinois Basin oil industry generates revenues in excess of $2.5 billion per year and pays millions in taxes each year. This money stays in America's heartland, and provides much needed jobs in primarily rural communities.

CountryMark was started by its member cooperatives, which are owned and controlled by individual farmers within our trade territory. Over 130,000 farmers in Indiana, Michigan, Illinois and Ohio participate in these local cooperatives, through which they benefit from ownership in CountryMark. CountryMark's Board of Directors is controlled by farmers. Each year, profits are distributed back to farmers via the cooperative system. In the past five years, CountryMark has returned patronage refunds of $213 million to its owners and the farm communities it serves.

II. CountryMark Sales Channel

CountryMark came into existence because the local cooperatives joined together to build a refinery in southern Indiana after the discovery of oil in the region. Our members wanted to ensure supply of quality fuels at market competitive prices. As a supply cooperative, CountryMark's mission is to provide those quality products that our members require for their independent fuel and lubricants businesses to be successful. Even though they own us through their investment, our members are not obligated to purchase our products. They only purchase products that the market desires and are profitable for their business. CountryMark works closely with our members to provide quality products that will be profitable for both parties.

Our member-owners are unique in that fuels and lubricants are only one aspect of their diversified business. Since they are heavily involved in agriculture, they are knowledgeable in the grain industry including corn and ethanol. Not only do our members supply seed, fertilizer and other farm needs to their local members, many own grain assets and are involved in buying and selling corn to ethanol producers. Arguably, our members are in the most sophisticated segment of the population with regards to grains, fuels, and the interplay of ethanol and corn. CountryMark has the unique position of being at the crossroads of petroleum and renewable fuels.

As such, CountryMark started using renewable fuels long before being required to do so by the Renewable Fuels Standard. Being a small refiner, CountryMark did not become an obligated party until January of 2011. Regardless, we started blending biodiesel in 2006 because our members and the segment of the marketplace that they served desired the product. CountryMark became a quality expert in biodiesel and a leader in sales. In fact, at one time, we operated four of the twelve direct biodiesel rack injection systems in the nation. CountryMark was recognized by Senator Richard Lugar with an Energy Patriot Award for our leadership in biodiesel. In 2008, we started blending 10% ethanol into our gasoline. Not only had the 10% ethanol blended gasoline (E10) become the accepted product in our market area, there were significant economic synergies with our refining operation that drove the decision to blend before being required. We recognize that there is a place for ethanol in the gasoline pool as long as it is accepted by consumers and is economically competitive.

III. The E10 Blendwall is Real

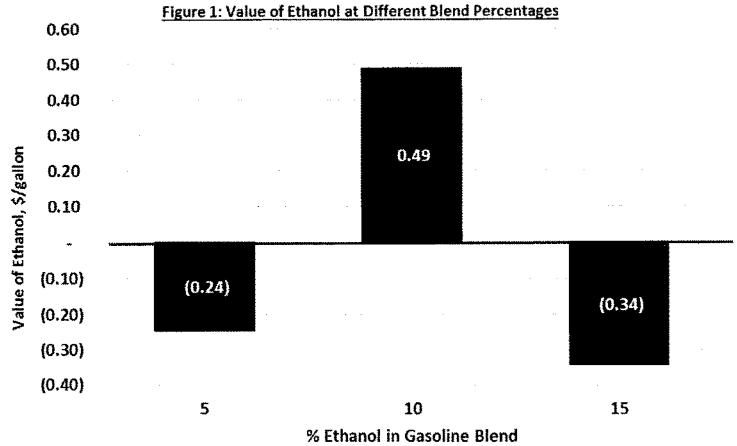
As defined by the EPA in the proposed standards for 2014 through 2016, the "E10 blendwall" represents the volume of ethanol that can be consumed domestically if all gasoline contains 10% ethanol and there are no higher-level ethanol blends consumed such as E15 or E85. It appears that EPA accounted for the blendwall in setting the 2014 and 2015 proposed standards for non-advanced biofuel or corn-based ethanol. The requirement for 2014 mirrors ethanol consumption of 13.25 billion gallons which equates to 9.7% ethanol in the blend and for 2015, the proposed 13.4 billion gallons of corn-based ethanol would equate to 9.7% ethanol in the blend based on EIA projections.

Even though EPA proposed standards for 2016 will exceed the blendwall, the marketplace reality is that E10 should be the maximum for several reasons: 1) the Clean Air Act (CAA) and subsequent regulations favor E10; 2) E10 is an economical compromise for the consumer and some refiners like CountryMark; and 3) the infrastructure required to dispense higher ethanol blends is prohibitive because low sales volumes do not provide a return on investment.

EPA regulations generated to comply with the CAA provide additional flexibility for ethanol blended gasoline. Title 40 Part 80 Subpart B Section 80.27 requires gasoline to have a Reid Vapor Pressure (RVP) of 9 pounds per square inch (psi) to be sold in the State of Indiana. EPA recognized that ethanol can contribute to the volatility of gasoline so specific blends between 9% and 10% ethanol (E10 blends) can be 1 psi above the standard limit – this is recognized as a 1 psi RVP waiver which is not available for higher ethanol blends. In essence, the E10 blendwall is created by the RFS, the CAA, and the physical properties of ethanol needing a RVP waiver which in turn favors the production of E10.

CountryMark started blending ethanol into gasoline in 2008, well before we were mandated to do so. CountryMark operates a proprietary pipeline and terminal system. We had ethanol blending infrastructure in place and were selling E10 blended gasoline. Our sales of E10 increased to the point where it made economic sense to switch to a lower octane base gasoline to accommodate the ethanol and take advantage of the additional octane that ethanol provides. When we analyze other ethanol blends, such as E15, this positive impact turns negative. Figure 1 shows the economic difference using current market conditions of different ethanol blends. This analysis is specific to CountryMark and may not represent the economics of other refiners; especially those that do not have terminal operations or the ability to blend ethanol into their gasoline products.

Figure 1: Value of Ethanol at Different Blend Percentages



For CountryMark, the ethanol blend that represents the economic optimum in today's market is E10. This is fundamentally driven by the fact that E10 is favored with the 1 psi RVP waiver. For different ethanol blends to be competitive, ethanol pricing would need to change to offset this disadvantage.

Today, E10 is the standard gasoline product in our market area and the majority of the country. Ethanol has a lower energy density than straight gasoline. In other words, there are less British Thermal Units (BTUs) per gallon in ethanol than gasoline. A gallon of ethanol contains 67% of the BTUs that gasoline without ethanol (E0) contains. For the consumer, as the percentage of ethanol increases, energy content decreases which translates to lower vehicle gas mileage. At E10, the effect on energy content is minimal – around 3%. Even though ethanol has lower energy per gallon, the consumer has accepted E10 as the standard gasoline in the market. Blends without ethanol now command a premium price over E10 and sales volumes are much lower than E10. This is reflected in ethanol consumption and the EPA's proposed standards for 2014 and 2015 which equate to a nationwide blend rate of 9.7%. Higher ethanol blends will have diminishing returns for the consumer due to lower gas mileage. This is especially apparent with E85, which has approximately 25% less energy per gallon than E10. Based on the economic impact to both consumers and refiners, higher blends such as E15 or E85 are facing and will continue to face a difficult road to becoming the standard gasoline in the market.

The infrastructure for higher ethanol blends is expensive for the independent gas station owner/operator. CountryMark members purchase products at wholesale from our terminal system and compete in the retail market to sell gasoline and diesel. CountryMark does not directly own retail facilities and does not subsidize infrastructure improvements unless it is related to branding. Therefore, our members and their partners own and operate retail stations. Typical retail station margins are small, less than a few pennies per gallon. In addition, most of our members' retail facilities are located in rural areas so gasoline sales are less than a half million gallons per year. These retail economics do not support the investment for dedicated infrastructure for higher ethanol blends. As an example, one of our members invested $37,000 to install pumps and piping for an E85 system and they used an existing tank. Installation of a new dedicated tank for E85 is estimated to cost $45,000. All combined a new installation to accommodate E85 or ethanol blend pumps would cost in excess of $80,000 per station. Due to the high cost and the apparent lack of consumer acceptance/demand discussed in the next section, our members are not currently pursuing the installation of E85 or blender pumps.

IV. E85 is Not the Answer

In the proposed RFS standards for 2014-2016, EPA stated that the 2016 proposed standards would challenge the E10 blendwall and intentionally drive towards gasoline blended with higher ethanol percentages. It has been theorized that increased sales of E85 could be the answer to the E10 blendwall. Based on CountryMark's experience, E85 is not the answer.

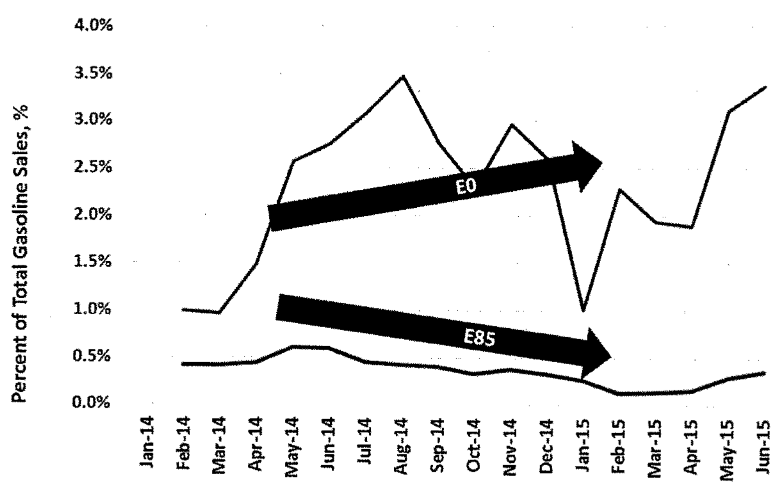
CountryMark sells E85 at our terminal racks and through our branded retail channel; however, we do not produce ethanol. All of the ethanol we sell, we purchase from various producers. We price our wholesale E85 product to recover our cost for purchased ethanol so basically it is a pass through to the customer.

Nationwide, it is estimated that only 6% of vehicles on the road today are flex fuel vehicles (FFV) and approximately 2% of retail stations offer higher ethanol blends. Being a Corn Belt state, the State of Indiana is above the national average in both FFV and infrastructure. Indiana has approximately 600,000 FFV out of 3 million passenger vehicles which is about 20% of the fleet. There are 211 gas stations in the state that offer E85. Currently, out of the 109 branded CountryMark stations, each owned and operated by independent businesses, 16 of those stations also sell E85. So 15% of CountryMark branded stations sell both E10 and E85. With this infrastructure and the high density of FFV, one would expect that E85 sales would make up a similarly high percentage of total gasoline sales. However, based on

CountryMark experience, especially the side-by-side comparison at retail stations that sell both E10 and E85, this is not the case.

Figure 2 shows CountryMark's E0 and E85 sales as a percentage of total gasoline sales for the past 18 months. E0 is represented in red and E85 is represented in blue. This comparison provides some interesting observations. First, CountryMark's sales of gasoline without ethanol (E0) makes up a higher percentage of our total gasoline than E85 sales. On average, E0 sales make up 2.3% and E85 sales make up 0.35% of total gasoline sales. In other words, we sell 6.5 times more E0 than E85. Note that E85

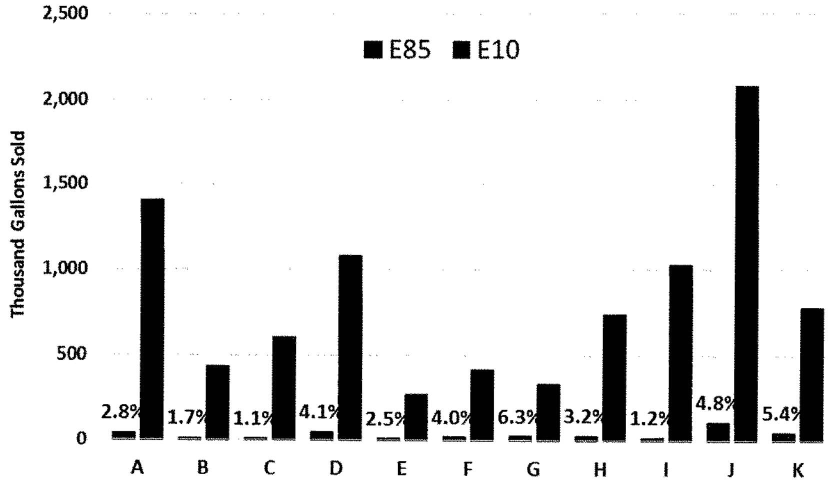
Figure 2: E0 and E85 Sales as a Percentage of Total Gasoline Sales



sales have not exceeded 1% of total sales volume. While seasonally adjusted E0 sales are increasing, E85 sales are decreasing, signaling that customer acceptance is in decline. Anecdotally, there appears to be an increased interest in E0 gasoline based on customer service inquiries and requests for brand literature. In fact, one of our members recently converted E85 pumps back to E0 service at two locations. To expand the analysis, we compared E10 and E85 sales at retail stations that sell both products side-by-side.

Currently, sixteen CountryMark branded stations offer both E10 and E85. Figure 3 presents a sampling of those stations that compares E85 sales compared to E10 sales over the past 18 month period. For these stations, E85 comprises approximately 3.5% of total station sales.

Figure 3: E85 vs E10 Sales at Same Stations



Data for 18-month period of January 2014 thru June 2015.

With 20% of the vehicles in Indiana being able to use E85, one would expect that the percentage of E85 sales would be greater than the average 3.5% that we see from CountryMark data. If a typical vehicle travels 12,000 miles per year with an average mileage of 30 miles per gallon, that vehicle would use about 400 gallons per year of E10. Since E85 has 25% less energy per gallon, a similar vehicle would use 500 gallons per year of E85. If every FFV in Indiana used E85, expected sales for the entire state would be estimated at 300 million gallons. Since CountryMark sells about 12.5% of the gasoline consumed in Indiana, we would expect our E85 sales to be near 37.5 million gallons per year if there was complete customer acceptance. However, in 2014, CountryMark sold a little over 1 million gallons or about 2.7% of the amount that would have been expected if customers were fully purchasing E85.

If E85 is not the answer, people may argue that biodiesel can fill the gap. However, we have similar experience with biodiesel blends. Recall that we started blending biodiesel in 2006 and are considered a leader in biodiesel blending. Our members and some of their customers wanted the product then and they still purchase it today; however, there are challenges. The main problem with biodiesel is cold weather properties. Biodiesel can start to gel at 35°F which causes filter plugging and vehicle operation problems. Because of this, our members do not purchase biodiesel starting November 1st through the middle of March. Biodiesel is not desired for nearly 40% of the year. In addition, even though we price biodiesel at the same price as diesel, we allow the customer to ultimately choose whether to purchase biodiesel or not – it is not a requirement. Within these constraints, currently, we average slightly less than 2% biodiesel in all of our diesel fuel.

In EPA's proposed standards for 2016, they "believe it is possible for the market to reach volumes perhaps as high as 600 million gallons (of E85) under favorable pricing conditions" and they present some scenarios in Table II.D.2.2 – Volume Scenarios Illustrating Possible Compliance with 3.40 Bill Gal Advanced Biofuel and 17.40 Bill Gal Total Renewable Fuel. The table provides E85 sales volumes between 100 and 600 million gallons. In 2014, EIA data shows that approximately 76.5 million gallons of E85 were supplied nationwide of which CountryMark sold 1.3%. To meet the EPA scenarios would require sales to increase between 31% and 684%. The EPA table also presents biodiesel volumes that when combined with EIA diesel consumption estimates would require 3.8% of the total diesel pool to be biodiesel. The EPA scenarios set an impractical and infeasible expectation for E85 and biodiesel use.

For CountryMark, the EPA's presented upper limit for E85 equates to 7.8 million gallons of sales per year. With the average annual sales for all gasolines at these 16 stations being 500,000 gallons per year, to meet the EPA projections nearly 100% of the gasoline sold would need to be E85. For biodiesel, EPA's projected 3.8% blend would be a 100% increase for CountryMark biodiesel sales. Due to the winter challenges with biodiesel, even requiring a 5% blend of biodiesel during the summer months would only result in an annual average of slightly over 3%.

Based on CountryMark experience, meeting both of these targets is infeasible. Experience shows that even with adequate availability of E85 in the market and sufficient FFV to use the fuel, consumers do not buy E85. In fact, E85 sales are decreasing and our members are converting E85 pumps back to E0 service. In addition, with a knowledgeable and supportive customer base, we cannot sell more that 2% biodiesel on average and reaching EPA's suggested levels is limited by winter operability. Therefore, E85 consumption and higher biodiesel blends should not be counted on to close the gap on the RFS mandates.

V. RFS Impact on CountryMark

CountryMark started selling ethanol blended gasoline and biodiesel long before being required to do so by the RFS. Being a small refiner, we did not become an obligated party until 2011. Therefore, we have only made slight changes to our operation due to the RFS. Since our customers are integrated with the agricultural community, they are high-end, knowledgeable users of renewable fuels – both ethanol and biodiesel. Even with this engaged customer base, our primary gasoline product is E10 and the sales of higher ethanol blends such as E85 only make up a small fraction of our sales. In addition, we can only sell slightly less than 2% biodiesel on an annual average of all diesel fuel.

Even with a customer base that favors renewable fuel blending when it comes to actual practice, CountryMark cannot blend enough renewable fuels to meet our annual obligation. This requires us to purchase Renewable Identification Numbers (RINs) in the marketplace. If the annual obligation continues to increase as indicated by the EPA there are only two options for compliance at this time:

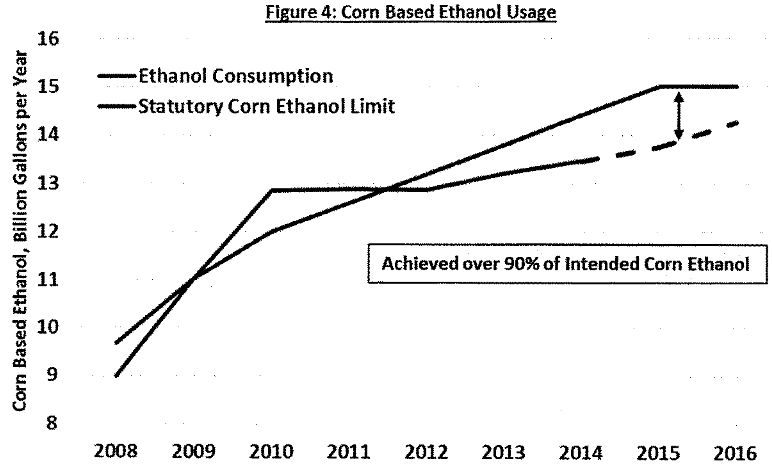
1) Purchase RINs to meet our obligation. For 2015, we are projecting a cost of over $4 million for additional RINs needed for compliance. This number will continue to increase and will pose an economic burden on the company. This will also impact our farmer-owners in that it will reduce income and patronage refunds.
2) Blend additional biodiesel. Diesel fuel specification, ASTM D-975, allows for up to 5% biodiesel to be blended within the specification. One approach would be to blend 5% biodiesel from March through November and not provide a choice to our customers. This lack of choice may negatively impact diesel sales volumes. Plus, this approach would still require purchasing additional RINs for compliance.

In the end, the RFS mandates will put an economic burden on CountryMark which puts the company at risk. The 2016 proposed standards require growth of E85 sales to meet the volume obligations; however, CountryMark data shows that E85 sales are decreasing which will widen the compliance gap. In addition, even by requiring our customers to purchase 5% biodiesel blends, we will fall short of our obligation and need to purchase RINs. The only thing the RFS does is raise our operating costs because without the RFS and its associated mandates, CountryMark would most likely continue to sell E10 gasoline and biodiesel at the current levels.

VI. Effect on Farmers and Corn Demand

CountryMark is a farmer-owned cooperative and our members are heavily involved in agriculture. We are at the crossroads of petroleum and renewable fuels. Previously, E10 and the difficulties of selling higher ethanol blends including both E15 and E85 were discussed. If the reality of the E10 blendwall continued to be reflected in the annual RFS standards and ethanol blending was limited to 9.7% nationwide, we must ask ourselves what effect would that have on corn consumption for ethanol and subsequently our farmer owners?

Figure 4: Corn Based Ethanol Usage



On average over the last 5 years, 40% of the U. S. corn crop has gone to ethanol production. The amount of ethanol mandated by the RFS has done little to change this percentage +/- 3%. Figure 4 provides a comparison of corn-based ethanol consumption versus the statutory limit for corn-based ethanol in EISA. Ethanol consumption through 2014 is EIA data (solid blue) and the dash line are estimated production numbers based on the proposed RFS standards. EPA rightfully recognized the E10 blendwall and lowered the corn-based ethanol requirement below the statutory limit. Even with this lower limit, the RFS will have achieved over 90% of the intended corn-based ethanol. Even if the corn-based ethanol was set at statutory limit, the incremental corn going into ethanol production would be small. For example, an additional billion gallons of corn-based ethanol would have used less than 3% of the total 2014 corn production. Corn-based ethanol production has limited upside to absorb more corn or a higher percentage of the corn crop. By any measure, the RFS will have consumed nearly all of its intended corn even if the annual standards are set at the blendwall. Therefore, setting the standards for corn-based ethanol with recognition of the E10 blendwall is a fair balance for providing the individual farmer owner with opportunities to sell corn for ethanol production while protecting their investment in CountryMark by not setting unachievable mandates.

VII. Conclusion

CountryMark started selling E10, E85 and biodiesel long before being required to do so by the RFS. To date, we have only made slight changes to our operation due to the RFS and without the RFS mandates we would continue to blend ethanol and biodiesel. Being part of a farmer-owned cooperative provides us with a knowledgeable customer base for renewable fuels – both ethanol and biodiesel. Even with this engaged customer base and selling ethanol and biodiesel blends, CountryMark cannot blend enough renewable fuels to meet our annual obligation under the RFS.

The solution for compliance does not include E85 because consumers do not want to purchase the fuel. Even though Indiana has a high density of FFV and CountryMark has a large percentage of stations that offer E85, data shows that on average E85 sales are only 3.5% of same store gasoline sales. Instead of E85 sales increasing, data shows they are decreasing at the same time that E0 blends being sold at a premium are increasing. These challenges point to the need for EPA to recognize that the E10 blendwall is real and set annual compliance obligations to recognize a maximum ethanol usage of 9.7% nationwide. This still meets over 90% of the original goal for corn-based ethanol which strikes a balance between corn growers and the reality of the blendwall. Otherwise, without practical ways to use renewable fuels that are accepted by the consumer, the RFS will become unworkable and companies like CountryMark will be financially threatened by the increased cost of purchasing RINs for compliance.

CountryMark appreciates the opportunity to testify today. As Congress continues to work through potential changes to the RFS that will strike a compromise for all parties and reflect the realities of the marketplace, CountryMark will continue to participate in this dialog.

Table of Acronyms

ASTM	American Society of Testing and Materials
CAA	Clean Air Act
BTU	British Thermal Unit (measurement of energy)
E0	Gasoline with 0% Ethanol
E10	Gasoline with 10% Ethanol
E15	Gasoline with 15% Ethanol
E85	Gasoline with 85% Ethanol
EIA	U. S. Energy Information Administration
EISA	Energy Independence and Security Act of 2007
EPA	U. S. Environmental Protection Agency
FFV	Flex Fuel Vehicles
PSI	Pounds per Square Inch (measurement of pressure)
RFS	Renewable Fuels Standard
RINs	Renewable Identification Numbers
RVP	Reid Vapor Pressure
U. S.	The United States of America

Chairman WEBER. Thank you, Mr. Smorch.
Dr. Hill, you're recognized for five minutes.

TESTIMONY OF DR. JASON HILL, ASSOCIATE PROFESSOR OF BIOPRODUCTS AND BIOSYSTEMS ENGINEERING, UNIVERSITY OF MINNESOTA

Mr. HILL. Chairmen, Ranking Members and Members of the Subcommittee, good morning, and thank you for inviting me to testify today. I am Jason Hill, Associate Professor of Bioproducts and Biosystems Engineering at the University of Minnesota and Resident Fellow of its Institute on the Environment.

My research focuses on understanding the environmental effects of the world's energy and food systems, and especially where they intersect in the growing bioeconomy. My work is funded by grants from the Department of Energy, USDA, EPA, and the State of Minnesota.

I am pleased to describe, as you have requested, my ongoing research into the environmental impacts of biofuels. Much of the research that I described today was conducted together with my colleagues Julian Marshall and Chris Tessum. I offer this testimony entirely on my own behalf.

One of the goals of the Renewable Fuel Standard is to reduce the negative environmental effects of transportation by increasing biofuels, but is this an effective approach? Are biofuels truly cleaner than conventional fuels?

To answer this question, we need to compare these fuels over their full lifecycle. That is, we need to consider the damage caused by producing them in addition to burning them. For gasoline, the lifecycle includes extracting and refining crude oil, distributing and combusting the gasoline itself. The lifecycle of corn ethanol involves growing and fermenting grain, and distilling, distributing, and combusting the ethanol itself.

Just how important is this lifecycle approach? If we were to ignore the pollution that is released when producing these fuels, as many others have done, we would underestimate their impacts. Take corn ethanol, for instance. Most of the pollution that contributes to increased fine particulate matter and ozone levels is emitted when it is produced, not when it is burned. We focused our analyses on these two pollutants as they cause the overwhelming majority of health pollution—air pollution health impacts.

Corn ethanol has higher lifecycle emissions than gasoline of five major pollutants that contribute to fine particulate matter and ozone levels. Cellulosic ethanol, which we explored as derived from corn stover, emits greater amounts of some pollutants than gasoline and lower amounts of others. It is also worth noting that using gasoline more efficiently, such as in a hybrid vehicle reduces emissions of all five pollutants.

How do these emissions affect human health? Well, that answer depends in part on where these emissions occur and where they travel, since what we really care about is how many people breathe dirty air and how much pollution they inhale. We therefore first estimated how levels of fine particulate matter and ozone change as a result of producing and using each fuel. We then calculated the damage to human health and well-being that would result from these changes in air quality.

We found that producing and using a gallon of gasoline in a conventional vehicle results in air quality-related health costs of about 50 cents per gallon. For corn grain ethanol, the cost is nearly double. This difference is largely due to ethanol production having greater pollutant emissions than gasoline production and not due to differences in tailpipe emissions, which are relatively small. Increased mortality from ethanol production and use occurs largely in the Midwest and Eastern United States. For both fuels, nearly all of the health damage is caused by fine particulate matter rather than by ozone.

We also found that producing and using a gallon of corn stover ethanol results in comparable costs to gasoline, again it's per gallon. Although increased mortality occurs in the Corn Belt, some areas, air quality improves.

Let's return to our original question of whether the Renewable Fuel Standard reduces the negative environmental effects of transportation. Our research shows that, at least with respect to air quality, that the answer is no. In fact, because the Renewable Fuel Standard has been met almost entirely with corn grain ethanol, it makes the air worse. This finding is consistent with the EPA's own findings, which found increasing average levels of fine particulate matter and ozone but up to 245 cases of premature mortality annually.

What role could cellulosic biofuels play in clearing the air? They have the potential to be no more damaging than gasoline and perhaps somewhat better. Still, they're not produced on a large scale and so their effects are less certain.

The Renewable Fuel Standard will continue to damage air quality as long as it supports corn grain ethanol regardless of how the cellulosic biofuel industry develops. Increasing the efficiency of corn grain ethanol may lessen its environment impacts, but even dramatic improvements would be unlikely to make it less damaging than gasoline.

Alternatively, we know that other options are likely to improve air quality, including increasing vehicle efficiency, electrifying vehicles with low-emission and renewable sources of electricity, promoting public transportation, and redesigning infrastructure. These are the options that we should be pursuing.

Thank you.

[The prepared statement of Mr. Hill follows:]

Statement of

Jason Hill, Ph.D.
Associate Professor
Bioproducts and Biosystems Engineering
University of Minnesota

before the

Subcommittee on Energy
Subcommittee on Oversight
Committee on Science, Space, and Technology
United States House of Representatives

on

The EPA Renewable Fuel Standard Mandate

July 23, 2015

Chairman Smith, Ranking Member Johnson, Chairman Weber, Chairman Loudermilk, Ranking Member Grayson, Ranking Member Beyer, and Members of the Subcommittees, good morning and thank you for inviting me to testify before you today. I am Jason Hill, Associate Professor of Bioproducts and Biosystems Engineering at the University of Minnesota and Resident Fellow of the University of Minnesota's Institute on the Environment.

My research focuses on understanding the environmental effects of the world's energy and food systems, and especially where they intersect in the emerging bioeconomy. My work is funded by grants from the U.S. Dept. of Energy, the U.S. Dept. of Agriculture, the U.S. Environmental Protection Agency, and the State of Minnesota. I recently served on the National Research Council's Committee on the Economic and Environmental Impacts of Increasing Biofuels Production.

I am pleased to describe, as you have requested, my ongoing research into the environmental impacts of biofuels, in particular the effects of corn ethanol, cellulosic ethanol, and gasoline on air quality. Much of the research that I will discuss today was conducted together with my colleagues Prof. Julian Marshall and Dr. Chris Tessum. I offer this testimony entirely on my own behalf.

One of the goals of the Renewable Fuel Standard (RFS2) is to reduce the negative environmental effects of transportation by increasing the use of biofuels, but is this an effective approach? Are biofuels truly "cleaner" than conventional fuels?

To answer this question, we need to compare these fuels over their full life cycle. That is, we need to consider the damage caused by producing them in addition to using them.[1] For gasoline, the life cycle includes extracting and refining crude oil, and distributing and combusting the gasoline itself. The life cycle of corn ethanol includes growing and fermenting grain, and distilling, distributing, and combusting the ethanol itself.

Just how important is this life cycle approach? If we were to ignore the pollution that is released when producing these fuels, as many others have done, we would underestimate their impacts.[2,3] For corn ethanol, for instance, most of the pollution that contributes to increased fine particulate matter ($PM_{2.5}$) and ozone (O_3) levels is emitted when it is produced, not when it is burned. We focused our analysis on these two pollutants as they cause the overwhelming majority of air pollution health impacts.

Corn ethanol has higher life cycle emissions than gasoline of five major pollutants that contribute to $PM_{2.5}$ and O_3 levels. (**Fig. 1**). Cellulosic ethanol, which is considered here as derived from corn stover, emits greater amounts of some pollutants than gasoline and lower amounts of others. It is also worth noting that using gasoline more efficiently, such as in a hybrid vehicle or other vehicle with improved fuel economy, reduces life cycle emissions of all five of these pollutants.

What is the effect of these emissions on human health? The answer depends in part on where these emissions occur and where they travel, since what we care about is how many people breathe dirty air and how much pollution they inhale.

To determine the effect of these fuels on human health, my colleagues and I first estimated how levels of $PM_{2.5}$ (**Fig. 2**) and O_3 (**Fig. 3**) change as a result of producing and using each fuel.[4] We then calculated the damage to human health that would result from these changes in air quality (**Fig. 4**) and monetized those costs (**Fig. 5**).

We found that producing and using a gallon of gasoline in a conventional vehicle results in air quality-related health costs of approximately $0.50 per gallon. For corn grain ethanol, the cost is nearly double. This difference is largely due to ethanol production having greater pollutant emissions than gasoline production and not due to differences in tailpipe emissions, which are relatively small. Increased mortality from ethanol production and use occurs largely in the Midwest and Eastern U.S. For both fuels, nearly all of the damage to human health is caused by $PM_{2.5}$ rather than by O_3.

We also found that producing and using a gallon of corn stover ethanol results in damage costs comparable to gasoline, again around $0.50 per gallon. Although increased mortality occurs in the Corn Belt and areas downwind, areas where coal is mined benefit from improved air quality. This is because corn stover ethanol production generates excess electricity that can offset electricity from coal.

Let us return to our original question of whether RFS2 reduces the negative environmental effects of transportation. Our research shows that, at least with respect to air quality, the answer is no. In fact, because RFS2 has been met almost entirely with corn grain ethanol, it makes the air worse. This finding is consistent with the U.S. EPA's own findings, which estimated RFS2 to increase average $PM_{2.5}$ and O_3 concentrations leading to up to 245 cases of premature mortality annually.[5,6]

What role could cellulosic biofuels play in cleaning the air? We found that they have the potential to be no more damaging than gasoline and perhaps somewhat better.[7] Still, because cellulosic biofuels are not yet produced on a large commercial scale, their effects are less certain than those of corn grain ethanol. There is, in fact, tremendous uncertainty about how the cellulosic biofuels industry will develop.[8,9] My colleagues and I recently showed that federal agencies differ dramatically in their projections of the types of biomass feedstocks that would be used to meet RFS2 (**Fig. 6**) and where these feedstocks would be produced (**Fig. 7**).[10]

RFS2 will continue to damage air quality as long as it supports corn grain ethanol regardless of how the cellulosic biofuel industry develops. Increasing the efficiency of corn grain ethanol production may lessen its negative health effects, but even dramatic improvements would be unlikely to make it a less damaging alternative to gasoline. Likewise, even ideal development of the cellulosic biofuel industry would likely result in only marginal improvements in the health impacts of transportation.

Alternatively, we know that other options are likely to improve air quality, including increasing vehicle efficiency, electrifying vehicles with low-emission and renewable sources of electricity, promoting public transportation, and redesigning infrastructure.[4] These are the options that we should pursue should we wish to make meaningful gains in reducing the damage that transportation causes to air quality.

Thank you again, Messrs. Chairmen, Ranking Members, and Members of the Subcommittees for the opportunity to be here today. I am happy to answer any questions you might have.

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Summary of major points

- The environmental effects of fuels must be compared on a life cycle basis, which means that we consider the consequences of both their production and their use.
- Corn grain ethanol has higher life cycle emissions than gasoline of five major pollutants that contribute to reduced air quality. These are primary fine particulate matter ($PM_{2.5}$), sulfur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs), and ammonia (NH_3).
- Corn grain ethanol worsens air quality in the Midwest and Eastern U.S. relative to gasoline by increasing levels of fine particulate matter ($PM_{2.5}$) and ozone (O_3) in the air.
- The air quality-related human health cost of producing and using gasoline is approximately $0.50 per gallon. For corn grain ethanol, it is nearly double.
- The air quality-related human health cost of producing and using cellulosic ethanol from corn stover is similar to that of gasoline.
- The monetized damages to human health from increased levels of $PM_{2.5}$ greatly exceed those of O_3 for each of the fuels considered.
- The Renewable Fuel Standard (RFS2), because it is currently dominated by corn grain ethanol, is responsible for reduced air quality over much of the U.S., which leads to increased mortality.
- Uncertainty in how the cellulosic biofuels industry will develop complicates projections of whether cellulosic biofuels will be better or worse for human health than gasoline or corn grain ethanol as relates to air quality.
- Improved vehicle efficiency, vehicle electrification using low-emission or renewable sources of electricity, public transportation, and redesign of infrastructure are better options for reducing the air quality impacts of transportation.

Figures

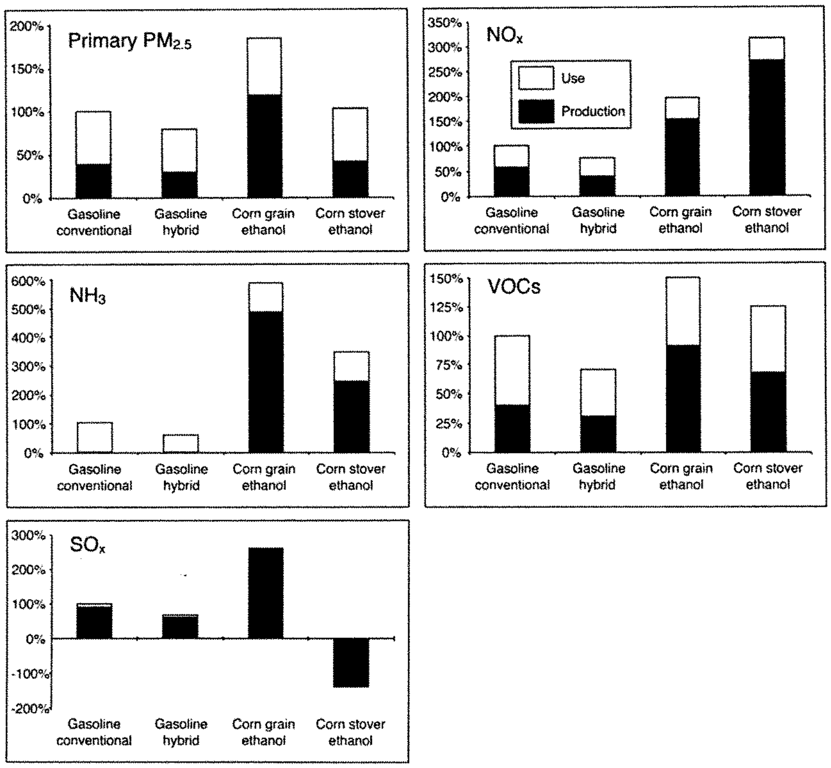


Figure 1. Life cycle emissions from fuel production and use. Values are indexed to gasoline.

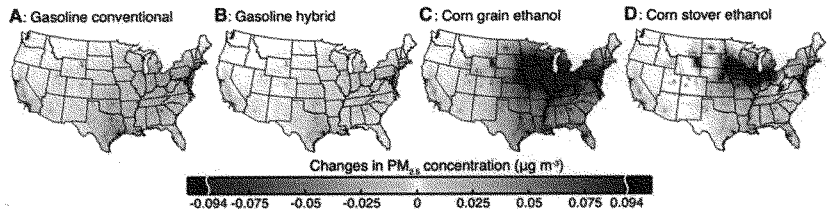


Figure 2. Changes in $PM_{2.5}$ concentrations from 10% of vehicle miles traveled by fuel.

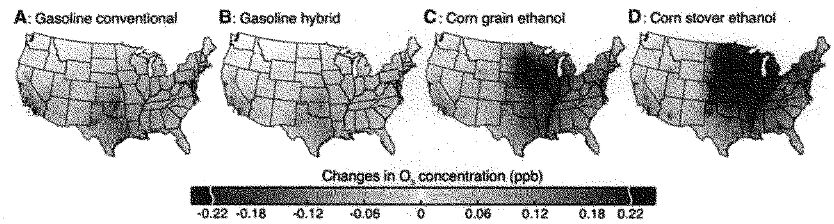


Figure 3. Changes in O_3 concentrations from 10% of vehicle miles traveled by fuel.

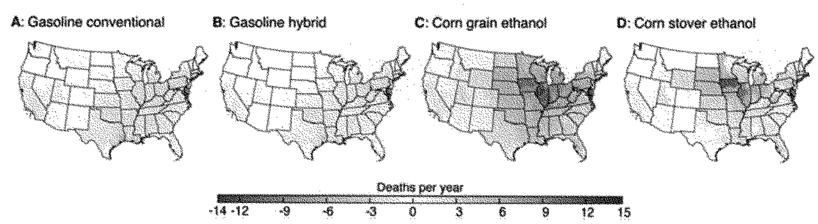


Figure 4. Annual human health damage from $PM_{2.5}$ aggregated by congressional district by fuel.

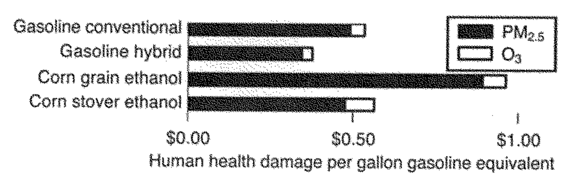


Figure 5. Monetized damage costs of fuel production and use by fuel.

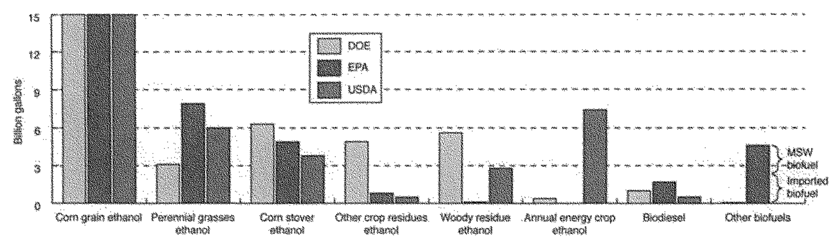


Figure 6. Federal agency projections of types of biomass produced to satisfy RFS2 in 2022.

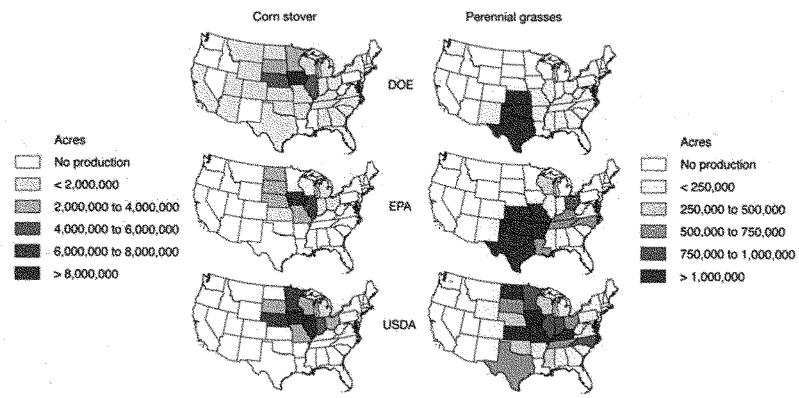


Figure 7. Federal agency projections of biomass production areas to satisfy RFS2 in 2022.

Biography – Jason Hill July 2015

Dr. Jason Hill is Associate Professor in the Department of Bioproducts and Biosystems Engineering at the University of Minnesota. He received his A.B. from Harvard University and his Ph.D. from the University of Minnesota. His research focuses on improving the sustainability of the world's food, energy, and natural resource systems by examining them from a life cycle perspective. Much of his research lies at their intersection, where he explores the environmental and economic effects of the emerging bioeconomy. His research is funded by the U.S. Department of Agriculture, the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the State of Minnesota Renewable Energy Development Fund. Recent awards include University of Minnesota McKnight Land-Grant Professor for 2012–2014, Resident Fellow of the Institute on the Environment for 2009–2015, and Oliver Smithies Visiting Lecturer at Balliol College of the University of Oxford in 2014. Dr. Hill recently served on the National Research Council's Committee on the Economic and Environmental Impacts of Increasing Biofuels Production and its Committee on Expanding Biofuel Production: Sustainability and the Transition to Advanced Biofuels. He currently serves on the U.S. Environmental Protection Agency Science Advisory Board's Biogenic Carbon Advisory Panel. Dr. Hill is on the editorial board of Environmental Research Letters.

Chairman WEBER. Thank you, Dr. Hill.
Mr. Red, you are recognized for five minutes.

TESTIMONY OF MR. CHUCK RED,
VICE PRESIDENT OF FUELS DEVELOPMENT
FOR APPLIED RESEARCH ASSOCIATES, INC

Mr. RED. Mr. Chairman, Ranking Members, thank you for the opportunity to speak here today. I'm Chuck Red, Vice President of Fuel Development at Applied Research Associates, known as ARA. ARA is a science and technology company with a thousand employee owners. ARA has conducted renewable fuel development since 2006.

The goal of my testimony today is to give you a snapshot of the future of second-generation renewable fuels and to discuss the central rule that the Renewable Fuel Standard plays in second-generation renewable fuel development, commercialization and industry growth.

Ethanol and methyl ester biodiesel are considered first-generation alternative fuels. First-generation fuels are characterized by small reductions in greenhouse gas emissions compared to petroleum and are typically blended at low rates with petroleum, five to ten percent. ARA has focused our research, development and commercialization efforts on second-generation alternative fuels. Our feedstocks—what we're putting into our fuels, what our fuels are made of—are fats, oils, and greases, many of which are waste products. These feedstocks can be from waste sources such as brown grease from water treatment or grease traps, yellow grease/used cooking oil, animal fats from rendering facilities. Other sources of feedstocks include algae and industrial/non-food crop oils. One promising non-food crop oil is Carinata. It's mustard seed. Carinata is being commercialized by a company called Agrisoma Biosciences. Crop oils such as Carinata can provide additional revenue for American farmers by growing it in rotation with the food crops that they're growing today. They can also serve to increase the yields of food crops such as wheat by breaking up the ground so the food crops can grow better. These rotation crops can also provide a very high-protein meal for animal feed as well.

ARA has teamed with a world leader in hydroprocessing technology, Chevron Limits Global, which is a 50/50 joint venture between Chevron and CBI Lummus for the commercialization and licensing of our patented 100 percent replacement renewable fuels production process. Our process is known as Biofuels ISOCONVERSION. The first phase of our process water as a catalyst at supercritical, high temperature and high pressure to quickly convert fats, oils, and greases into a renewable crude oil. This renewable oil, when hydrotreated, has the same molecular makeup and boiling range distribution as petroleum crude. As a result, our process makes a 100 percent replacement for petroleum crude, allowing jet fuel and diesel fuel made with our technology to meet petroleum specifications, without blending with petroleum-based jet or diesel fuel. To our knowledge, our technology produces the only jet and diesel fuels being tested by the U.S. military that are 100 percent replacements for petroleum-based jet fuel.

In 2012, the National Research Council of Canada flew a jet plane with the first-ever 100 percent biofuels phase of flight that met all petroleum standards using our jet fuel which we call ReadiJet. ReadiJet was demonstrated to meet all petroleum jet fuel standards without blending. Our fuels have been tested by numerous engine manufacturers including GE, Rolls Royce, Pratt and Whitney, and Honeywell. Our ReadiJet produces over less than 50 percent of the emissions and particulate and black carbon of petroleum jet fuel while reducing lifetime greenhouse gas emissions by more than 80 percent. Significantly, in jet engine tests, ReadiJet was more efficient than its petroleum counterpart, requiring 1.5 percent less fuel to produce the same amount thrust. ReadiJet and ReadiDiesel fuels are being certified as 100 percent drop-in replacement fuels by the U.S. Navy right now. In May, we delivered over 50,000 gallons of fuel for certification to the U.S. Navy, and we are going to deliver an additional 90,000 gallons of fuel for certification to the Navy in fiscal year 2016.

ARA and our partners, Chevron Lummus Global, have cleared some of the toughest hurdles towards full certification and adoption of ReadiJet and ReadiDiesel as replacements for petroleum fuels. I am proud of our team and thankful for all of the support that we have had from our testing partners and feedstock partners. We are producing fuels at 100 barrel per day unit operated by Blue Sun Energy, one of our licensees, at their facility in St. Joseph, Missouri, now.

Taking new technology to commercial scale is perhaps the most challenging task of all. We have four commercial licensees of our Biofuels ISOCONVERSION technology. Two producers have begun engineering and design for production facilities to provide renewable jet and diesel fuel for the Navy, airlines, and other aviation and diesel fleet customers. Each of our licensees is counting on the Renewable Fuels Standard to provide a market for renewable jet and diesel fuel to support the investment of tens of millions of dollars to produce 100 percent drop-in ReadiDiesel, ReadiJet, and other high-value byproducts, at scale.

Two of our licensees, Aemetis and Blue Sun Energy, are currently operating commercial plants producing a combined 100 million gallons per year of first-generation renewable fuels and are looking forward to the RFS providing the power behind moving towards next-generation fuels.

Thank you.

[The prepared statement of Mr. Red follows:]

Good morning. I am Chuck Red, Vice President of Fuels Development at ARA. ARA is a science and technology company with 1000 employee owners. ARA has conducted renewable fuel development since 2006.

The goal of my testimony today is to give you a snapshot of the future of second generation renewable fuels, what lies around the corner, and to discuss the role that the RFS plays in second generation renewable fuel development, commercialization, and industry growth.

Ethanol and methyl ester biodiesel are considered first generation alternative fuels. First generation fuels are characterized by small reductions in Green House Gas (GHG) emissions compared to petroleum fuels and are typically blended at low rates with petroleum.

ARA has focused our research, development and commercialization efforts on second generation alternative fuels. Our feedstocks are fats, oils, and greases. These feedstocks can be from waste sources such as brown grease from water treatment or grease traps, yellow grease/used cooking oil, and animal fats. Other sources of feedstocks include algae and industrial/non-food crop oils. Two promising non-food crop oils are Carinata, which is being commercialized by Agrisoma biosciences and Pongamia, which is being commercialized by Terviva. Crop oils such as Carinata can provide additional revenue for American farmers by growing it outside of food growing cycles.

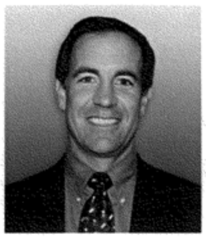
We are teamed with Chevron Lummus Global, a fifty-fifty joint venture between Chevron and CBI Lummus, on the commercialization and licensing of our conversion process. This process is known as Biofuels ISOCONVERSION. Our process uses high temperature/high pressure, supercritical water to quickly convert fats, oils, and greases into a renewable crude oil. This oil, when hydrotreated, is a pure hydrocarbon with the same chemistry as petroleum, but without sulfur, nitrogen, or other impurities that produce atmospheric pollutants when combusted. Our process makes a 100% replacement for petroleum crude. Jet fuel and diesel fuel made with our technology meet all petroleum specifications, without blending. In 2012, National Research Council (NRC Canada) flew the first ever 100% biofuels flight that met all petroleum standards, using our jet fuel which we call ReadiJet. ReadiJet is a fuel that meets petroleum jet fuel standards, without blending. Our ReadiJet and ReadiDiesel fuels have been tested by numerous engine manufacturers including GE, Rolls Royce, Pratt and Whitney, and Honeywell. Our ReadiJet produces over 50% less emissions and black carbon than petroleum jet fuel while reducing lifetime greenhouse gas emissions by over 80%. In jet engine tests, ReadiJet was more efficient than its petroleum counterpart, requiring 1.5% less fuel to produce the same thrust.

ReadiJet and ReadiDiesel fuels are being certified as 100% drop-in fuels by the US Navy. In May, we delivered over 50,000 gallons of fuel for certification to the US Navy. We will deliver an additional 90,000 gallons of fuel to the US Navy in FY16.

ARA has cleared some of the toughest hurdles, and I am very proud of our team and thankful for all of the support that we have received from our many testing and feedstock partners. We are working at a 100 barrel per day scale with Blue Sun Energy, one of our licensees, at their facility in St Joseph, MO. Taking new technology to commercial scale is perhaps the most challenging task of all. ARA and CLG now have four commercial licensees of our Biofuels ISOCONVERSION technology. Two have begun front end engineering and design. Each of our licensees is counting on the Renewable Fuels Standard as a risk reducer as they invest tens of millions of dollars to produce 100% drop-in ReadiDiesel, ReadiJet fuel, and other high value by-products, at scale.

Commercializing second generation renewable fuels is an important step in reducing US dependence on imported oil, through lower greenhouse gas emission domestic alternatives. Our technology is one of a number of pathways that can access waste feedstocks, producing fuels that have the promise of being cost competitive with petroleum. Two of our licensees, Aemetis and Blue Sun Energy, are currently operating plants producing first generation alternative fuels. They are the entrepreneurs that took the risk and successfully scaled up first generation alternative fuels. The Renewable Fuels Standard played an important role in providing support for the scaling of ethanol and biodiesel and for providing momentum for technology companies like ARA and Chevron Lummus Global to see a future for low greenhouse gas emission fuel solutions. Our momentum continues as we develop compelling solutions for production of these fuels that are cost competitive with petroleum, take advantage of waste and industrial oil feedstocks, and reduce greenhouse house emissions.

The Renewable Fuel Standard has been the main tool of US biofuels policy. It can continue to play that role in scaling second generation renewable fuels and feedstocks by continuing to increase volumetric obligations and by providing consistent policy which spurs investment in second generation fuel production facilities. We encourage Congress to continue to provide support for the Renewable Fuels Standard as it contributes to the investment in production and distribution of domestic, low-carbon, advanced biofuels.



Chuck Red is a Vice President at Applied Research Associates (ARA) and has served as the Fuels Development Program lead since 2009. During this time, he has led the development and commercialization of ARA's fuels program based on the Catalytic Hydrothermolysis technology. Under his leadership, ARA's ReadiJet has moved from bench to demonstration scale and has been included in test programs with US Navy and Air Force, Rolls Royce, Pratt and Whitney, US Air Force Research Lab, and Naval Air Systems Command. In October 2012, ReadiJet was flown in the first 100% biofuels flight with National Research Council Canada, named one of Popular Science's Top 25 Science Events of 2012. Biofuels Digest awarded ARA's ReadiJet the top new fuel of 2012, as well.

During his 10 years with ARA he has led ARA's North Florida Division, one of the most diverse business units in ARA, with 110 engineers and scientists conducting work in Environmental Process Development, Medical Technology Development, Alternative Fuels, Training Solutions, CBRN-E program management, Video Production, Creative Graphic Design, Emergency Management, and Navy Systems Support. Chuck also led the Navy Systems Group, directing testing of the Deployable Joint Command and Control (DJC2) system and Landing Craft Air Cushion (LCAC) C4N system at Naval Surface Warfare Center, Panama City Division.

Prior to ARA, Chuck's career included service as a Naval Flight Officer with more than 2,000 flight hours and 150 carrier landings in the F-14 Tomcat with the VF-142 Ghostriders and VF-14 Tophatters. During his Navy career, he also served as the Operational Test Director for the F-14D aircraft and weapons system.

Chuck is a United States Naval Academy graduate with a BS in Electrical Engineering and Minor in German. He earned his MS in Business Management from Troy State University. Chuck and his wife Lisa have six children and live on a gentleman's farm in Panama City, Florida.

Chairman WEBER. Thank you, Mr. Red.
Mr. Reid, you are recognized for five minutes.

TESTIMONY OF MR. TIM REID, DIRECTOR OF ENGINE DESIGN, MERCURY MARINE

Mr. REID. Good morning, Chairmen Weber and Loudermilk, and Members of the Energy and Oversight Subcommittees. It's a pleasure to be here this morning to discuss the Renewable Fuel Standard, E15, and its particular impact on the recreational boat community. My name is Tim Reid, and I'm the Director of Engine Design and Development at Merc Marine, a division of Brunswick Corporation, located in Fond du Lac, Wisconsin.

Mercury Marine has been a member of—manufacturer of recreational marine engines continuously since 1939, and currently makes and sells more engines than any other marine manufacturer in the world.

I am here today to discuss the Renewable Fuel Standard and E15 fuels on behalf of the National Marine Manufacturers Association, which represents over 1,500 boat builders, marine engine and marine accessory manufacturers.

The vast majority of the current production marine engines are open loop with no capability to correct for oxygenated fuels. This is especially true for the in-use fleet which is recognized to be over 40 years old.

The key point to remember when considering ethanol blending is its effect as an oxygenator. On a typical marine engine, the additional oxygen makes the fuel burn hotter, and the higher temperatures can reduce the strength of the metallic components. Run-quality issues can also occur when the engine operates leaner than its combustion system limits. In addition, ethanol can cause compatibility issues with materials in the fuel systems because of the chemical interaction. A study conducted by DOE, NREL and Volvo Penta showed that the 4.3-liter sterndrive engine, when durability tested on E15, exhibited emissions degradation beyond its certification limit. In addition, throughout its testing, the engine exhibited poor starting characteristics during both hot restart and cold-start conditions.

While I discuss the findings of another E15 study, I'd like to show you a few photos of the engine components after endurance testing to illustrate the results. A similar study conducted by DOE, NREL, and Mercury Marine was completed to investigate the emissions, performance and durability of running a 15 percent ethanol blend on outboard marine engines during 300 hours of wide open throttle endurance testing—a typical marine engine durability cycle. Three separate engine families were evaluated. A 9.9-horsepower carbureted four-stroke engine and a 300-horsepower supercharged electronic fuel-injected four-stroke engine represented engines currently in production. A 200-horsepower electronic fuel-injected two-stroke engine was chosen to represent the legacy products still used widely today. Only one of the engines tested on E15 completed 300 hours without failure. Test results showed poor run quality, including misfires at the end of the test, causing an increase in exhaust emissions. In addition, there were increased carbon deposits in the engine on the underside of the pistons and on the ends of the connecting rods, clearly exhibiting higher operating temperatures. Additionally, deterioration of the fuel pump gasket was evident, likely due to material compatibility issues with the fuel blend. This deterioration of the gasket could lead to fuel pump failure, disabling the engine. The other two engines tested on E15 catastrophically failed prior to completion of the endurance test. One engine failed a connecting rod bearing and the other failed three exhaust valves. Critical engine components like pistons and connecting rods again documented increased temperatures due to running on E15.

E15 does not only deteriorate the engine but also puts the boat fuel systems at risk. While studies have been conducted on E15 in engines, marine fuel tanks and fuel lines were never tested, or certified, for use in anything over E10. Prior to 1990, they were not even certified for E10. Deteriorated fuel lines inside the boats could lead to fuel leakage and a greater risk of fire and explosion. Marine fuel systems, prior to 2012, were completely open vented, so E15 would dramatically increase evaporative emissions as ethanol increases fuel volatility, especially if the RVP waiver is allowed. E15 creates a higher probability of phase separation with water in the fuel tank resulting in a greater chance of disabling the boat engines and stranding a boater out on open water.

NMMA and the marine industry are not opposed to all ethanol fuel blends. We feel however, that the RFS is a deeply flawed legislative mandate which is leading this country in a direction that will significantly harm not only marine engines, but other non-road engines and automobiles, and in turn the consumers of these products. The overwhelming majority of non-road engines, from chainsaws to weed trimmers to lawn mowers, operate similarly to recreational marine engines with open loop fuel systems including a carburetor that is set at the factory and designed to be, and required by EPA to be, tamper proof. When the fuel changes in the marketplace and additional oxygenates are added, such as by going from E10 to E15, engines run hotter, causing serious durability issues and increased emissions either in the form of increased nitrogen oxides or increased hydrocarbons.

The absurdity of it is, by using higher ethanol blends to achieve the mandates of the RFS, we are actually increasing emissions and lowering efficiency. Driven by a mandate rather than sound science, EPA has allowed E15 to be sold in the marketplace even with documented studies showing durability issues.

NMMA is not anti-ethanol, but simply opposed to fuel blends that destroy our engines. For the past five years, NMMA, Mercury Marine, Honda, and the United States Coast Guard, along with the U.S. Department of Energy, Argonne National Labs, and BRP/Evinrude have been proactively working to evaluate a better alternative to ethanol, both as an oxygenate and a biofuel. Isobutanol has an energy content closer to that of gasoline, making it more compatible with existing engines and fuel systems. Isobutanol is considered an advanced biofuel in the RFS and can be produced from many different types of biomass feedstock, including corn. NMMA has conducted tests on a variety of marine engines and vessels using 16.1 percent isobutanol by volume, which has similar oxygen content to E10, avoiding the negative properties of E15 identified above. The results of our documented and published research thus far indicate that isobutanol at 16.1 percent volume yields very similar engine emissions, durability, power and performance as E10.

NMMA supports Congressman Goodlatte's bill, H.R. 704, and believes it takes the appropriate steps to amend the Renewable Fuel Standard by freezing ethanol at E10 and makes other needed changes to assess our biofuel needs. I strongly urge members of this Committee to take a serious look at the RFS and move steadfast in reforming this ill-advised mandate.

I appreciate the opportunity to come before the Committee today and is happy to answer questions. Thank you.

[The prepared statement of Mr. Reid follows:]

Testimony of Tim Reid

Mercury Marine

Fond du Lac, Wisconsin

Before the House Science, Space and Technology Committee

Subcommittees on Energy and Oversight

July 23, 2015

Good Morning, Chairmen Weber and Loudermilk and members of the Energy and Oversight Subcommittees

It is a pleasure to be here this afternoon to discuss the Renewable Fuel Standard, E15 and its particular impact on the recreational boating community. My name is Tim Reid, and I am the Director of Engine Design and Development at Mercury Marine, a division of the Brunswick Corporation, located in Fond du Lac, Wisconsin. Mercury Marine has been a manufacturer of recreational marine engines continuously since 1939, and currently makes and sells more engines than any other marine engine manufacturer in the world. I am here today to discuss the Renewable Fuel Standard, and E15 Fuels on behalf of the National Marine Manufacturers Association, which represents over 1500 boat builders, marine engine, and marine accessory manufacturers.

The vast majority of current production marine engines are open-loop with no capability to correct for oxygenated fuels. This is especially true for the in-use legacy fleet which is recognized to be 40 years old. The key point to remember when considering ethanol blending, is its effect as an oxygenator. On a typical marine engine, this additional oxygen makes the fuel burn hotter, and the higher temperatures can reduce the strength of the metallic components. Run quality issues can also occur when the engine operates leaner than its combustion system limits. In addition, ethanol can cause compatibility issues with materials in the fuel systems because of the chemical interaction.

A study conducted by DOE, NREL and Volvo Penta showed that the 4.3L sterndrive engine, when durability tested on E15, exhibited emissions degradation beyond its certifications limit. In addition, throughout its testing the engine exhibited poor starting characteristics during both hot restart and cold-start conditions.

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A similar study conducted by DOE, NREL, and Mercury Marine was completed to investigate emissions, performance and durability of running a 15% ethanol blend on outboard marine engines during 300 hours of wide open throttle (WOT) endurance testing—a typical marine engine durability test. Three separate engine families were evaluated. A 9.9 HP carbureted four-stroke engine and a 300 HP supercharged electronic fuel injected (EFI) four-stroke engine represented engines currently in production. A 200 HP electronic fuel injected (EFI) two-stroke engine was chosen to represent the legacy products still in widespread use today.

Only one engine tested on E15 completed 300 hours without failure. Test results showed poor run quality, including misfires at the end of the test causing an increase in exhaust emissions. In addition, there were increased carbon deposits in the engine on the underside of the pistons and on the ends of the connecting rods clearly exhibiting higher operating temperatures. Additionally, deterioration of the fuel pump gasket was evident, likely due to material compatibility issues with the fuel blend. This deterioration of the gasket could lead to fuel pump failure, disabling the engine.

The other two engines tested on E15 catastrophically failed prior to completing the endurance test. One engine failed a rod bearing and the other failed 3 exhaust valves. Critical engine components like pistons and connecting rods again documented increased temperatures due to running on E15.

E15 does not only deteriorate the engine but also puts the boat fuel system at risk. While studies have been conducted on E15 in engines, marine fuel tanks and fuel lines were never tested, or certified, for use in anything over E10. Prior to 1990, they were not even certified for E10. Deteriorated fuel lines inside boat hulls could lead to fuel leakage and a greater risk for fire or explosion. Marine fuel systems, prior to 2012, were completely open vented, so E15 would dramatically increase evaporative emissions as ethanol increases fuel volatility, especially if the RVP waiver is allowed. E15 creates a higher probability of phase separation with water in the fuel tank resulting in a greater chance of disabling the boat engines and stranding a boater out on the open water.

NMMA and the marine industry are not opposed to all ethanol fuel blends. We feel however, that the RFS is a deeply flawed legislative mandate which is leading this country in a direction that will significantly harm not only marine engines, but other non-road engines and automobiles, and in turn the consumers of these products. The overwhelming majority of non-road engines, from chainsaws to weed trimmers to lawn mowers, operate similarly to recreational marine engines with open loop fuel systems including a carburetor that is set at the factory and designed to be—and required by EPA to be--tamper proof.

When the fuel changes in the marketplace and additional oxygenates are added—such as by going from E10 gasoline to E15—engines run hotter, causing serious durability issues and increased emissions either in the form of increased Nitrogen Oxides or increased hydrocarbons. The absurdity of it all is, by using higher ethanol blends to achieve the mandates of the RFS, we are actually increasing emissions and lowering efficiency. Driven by a mandate rather than sound science, EPA has allowed E15 to be sold in the marketplace even with documented studies showing engine failures.

NMMA is not anti-ethanol, but simply opposed to fuel blends that will destroy our engines. For the past five years, NMMA, Mercury Marine, Honda, and the United States Coast Guard, along with the US Department of Energy, Argonne National Laboratories, and BRP/Evinrude have been proactively working to evaluate a better alternative to ethanol, both as an oxygenate and a biofuel. Isobutanol has an energy content closer to that of gasoline, making it more compatible with existing engines and fuel systems. Isobutanol, is considered an advanced biofuel in the RFS and can be produced from many different types of biomass feedstock, including corn. NMMA has conducted tests on a variety of marine engines and vessels using 16.1% isobutanol by volume, which has similar oxygen content to E10, avoiding the negative properties of E15 identified above. The results of our documented and published research thus far indicate that isobutanol at 16.1% by volume yields very similar engine emissions, durability, power and performance as E10.

As an engineer intimately aware of the negative effects of high ethanol fuel, I can say the move towards E15 and possibly even higher blends, to achieve the 36 billion gallon requirement of the RFS is flawed.

Rather than continue on a biofuel path that does nothing for lowering emissions and harms our engines, I believe we must freeze the ethanol content of gasoline at its current level of 10% by volume and look towards alternative energy sources that make sense for the engines which must run on them.

Unless and until Congress acts on the RFS, EPA will continue to implement the deeply flawed RFS without regard to its ramification on engines or consumers. This is a nonsensical path that creates a fuel supply incompatible with engine technology which destroys engines, increases emissions, and puts boat fuel systems in jeopardy.

NMMA supports Congressman Goodlatte's bill, H.R. 704, and believes it takes the appropriate steps to amend the Renewable Fuel Standard by freezing ethanol at E10 and makes other needed changes to assess our biofuel needs. I strongly urge members of this committee to take a serious look at the RFS and move steadfast in reforming this ill-advised mandate.

I appreciate the opportunity to come before this committee today and am happy to answer any additional questions.

Tim is currently the Director of Engine Design and Development for Mercury Marine. Tim manages the design and validation of Mercury's combustion engines including sterndrive and outboard products. He also conducts Advanced Engineering projects, which include the investigations of alternative fuels. These include the effects of E15 on marine engines and the Isobutanol CRADA with the United States Coast Guard.

Tim earned his undergraduate degree in Mechanical Engineering at the University of Iowa. He earned a Masters in Mechanical Engineering from the University of Wisconsin where he conducted research in the Engine Research Center.

Tim started his career at General Motors and worked at GM Powertrain in the Advance Powertrain Group. He worked on a number of engine programs where he designed engine components in addition to combustion and performance development. He joined Mercury Marine in 1995 and has progressed through several assignments including the design and development of all of Mercury's current 4-stroke outboard and sterndrive products. Tim has been instrumental in engine design and development for 26 years, is a member of the Society of Automotive Engineers, and is an active boater.

Chairman WEBER. Thank you, Mr. Reid.

I'm going to recognize myself for five minutes. I'm going to make a couple of comments too. I said to somebody, my dad owned a gas station growing up that he built in 1958 when I was but five years old, an Amoco gas station, and he sold Amoco white gas that was 100 percent octane and could be used in Coleman lanterns, it was so clean. I owned an air conditioning company, so I'm extremely aware of the BTU heat content and energy, so this is very, very interesting to me.

Mr. Smorch, you addressed this in your written testimony but can you provide your assessment of the demand? I want you to reiterate CountryMark's sales E0, E10, E15 and E85. You basically said, did you not, that you guys—you have farmers that are owners of the company. Is that right?

Mr. SMORCH. That is correct.

Chairman WEBER. And so—and they raise corn, some of them, is that right?

Mr. SMORCH. That is correct.

Chairman WEBER. Would you call that a vested interest?

Mr. SMORCH. Yes, very much so.

Chairman WEBER. Okay. Can you address your assessment on the demand for those four categories, E0, 10, 50, and 85? Go back through that one more time for us, would you?

Mr. SMORCH. Sure. Well, first of all, the majority of our gasoline that we sell is E10. We believe that the blend wall is a real limit on how much ethanol can go into gasoline. We have no experience with E15 because E15 is more expensive to produce from a refiner's standpoint and so we have not gone there. Plus, there's a lot of other issues with E15 that are too lengthy to get into.

The one thing to reiterate, though, and this is where the EPA—what the EPA is looking at for the renewable fuel standards in '16 is that they're saying that E0 with no ethanol is going to actually have to decrease, but we're seeing in our marketplace that E0 is increasing and people are actually requesting to have more E0 available. At the same time, as I said in my testimony, E85 sales are decreasing and——

Chairman WEBER. Why is that? Why don't they want to buy E85?

Mr. SMORCH. You know, I can't tell whether it's energy value or not. All I know is that when we look at the same stations that sell E85 and E10 side by side, people are not choosing to put E85 in their vehicles.

Chairman WEBER. So it's market-driven. And is it true that E85 actually is not as—puts more emissions in the air and it's not as fuel-efficient, so in essence, we wind up using more fuel to go the same distance that we would have had we used E10?

Mr. SMORCH. Yeah. I'm not an expert in the emissions side of it, but on the energy content of the E85, it's 25 percent less energy——

Chairman WEBER. Well——

Mr. SMORCH. —than E10.

Chairman WEBER. —so you would use, for example, to go—you would use 25—say 100 gallons or 125 gallons—I'm just thinking if you're going to have to use 125 gallons of the E85 as opposed to the 100 gallons, it's going to put more emissions in the air while you're using that extra 25 gallons.

In your experience, do—well, let me do this. Does it surprise you that the EPA doesn't even meet the requirements for coming out with a new standard, although they're by law? Would you guys be fined if you didn't meet the new requirements by law?

Mr. SMORCH. Well, we would have—yeah, we would be fined.

Chairman WEBER. You would be fined but—EPA did not get fined when they didn't meet the requirement of law to come out with that standard, did they?

Mr. SMORCH. Well, not that I'm aware of.

Chairman WEBER. Oh, I'm aware of it.

Let me go to all witnesses very quickly. Ten years ago next month President Bush signed into law an energy bill that included the renewable fuel standard. The RFS came with lots of promises, including being the answer to achieving energy independence, cleaner air, consumer savings, and even defeating terrorism. Based on your research and experiences, has RFS achieved these promised benefits?

And it's two parts of a question. Has it achieved these benefits—let me go back—energy independence, clean air, consumer savings, and defeating terrorism. It sounds like we've got some negotiation with Iran going on that terrorism hadn't been defeated. Based on your research and your experience, have those four things occurred, Mr. Smorch?

Mr. SMORCH. I would say at this point they probably have not occurred.

Chairman WEBER. Dr. Hill?

Mr. HILL. No, they have not.

Chairman WEBER. Mr. Red?

Mr. RED. We have not reached that goal. We're working towards that.

Chairman WEBER. Okay. Mr. Reid?

Mr. REID. My opinion would be no.

Chairman WEBER. Would be no. So one of you asked isn't it time for Congress, and indeed I said it is, to reevaluate the law. So would y'all agree with that? Just a simple yes or no. Isn't it time for Congress to reevaluate that law, Mr. Smorch?

Mr. SMORCH. Yes, it is.

Chairman WEBER. Dr. Hill?

Mr. HILL. Yes.

Chairman WEBER. Mr. Red?

Mr. RED. I'm an expert on renewable fuel generation and technology so I'm not going to comment on that one.

Chairman WEBER. You're not going to comment on that one? You're taking the Fifth Amendment. Is that E–Fifth, E5?

Mr. PERLMUTTER. Point of order. The witnessess have right.

Chairman WEBER. Okay. I didn't know there was order here but thank you for pointing that out.

Mr. Reid?

Mr. REID. Per my testimony, yes.

Chairman WEBER. Yeah, thank you. Okay. Well, I appreciate that and I am going to yield to the Ranking Member for questions.

Mr. GRAYSON. Thank you, Mr. Chairman.

Brazil, a Third World country, has had an ethanol requirement since 1931, and for the past 40 years Brazil has had a requirement of E10 or greater. For the past 20 years, it's had a requirement in the neighborhood of E25. Can anyone explain to me why Brazil can do it and we can't? Let's start with you, Mr. Smorch.

Mr. SMORCH. I can't answer that question. I'm not an expert in Brazil and how the interaction between their gasoline market goes.

Mr. GRAYSON. Well, Mr. Reid, correct me if I'm wrong but Brazil has boats, right?

Mr. REID. Yes, they do.

Mr. GRAYSON. Okay. And lawnmowers? They have lawnmowers?

Mr. REID. Yes.

Mr. GRAYSON. Chainsaws?

Mr. REID. I believe so.

Mr. GRAYSON. So why can Brazil do it and we can't?

Mr. REID. We know within our marine engines, first of all, when our marine engines go there, we have no warranty because of the fuel requirements, so we drop the warranty. They are not covered under our mercury warranty.

The other part of it is we believe they're locally modified to run on this fuel and the beauty——

Mr. GRAYSON. Okay. All right. Stop right there.

Mr. REID. All right.

Mr. GRAYSON. Locally modified to run on that fuel. So that's how they deal with it. They get that done. Why couldn't we do the same thing?

Mr. REID. The key thing is that then they have a renewable—a consistent fuel source that every day they go to the fuel pumps they're getting E20.

Mr. GRAYSON. Which is what we should have here, right?

Mr. REID. The challenge there is that our customers or our consumers of our marine engines can pull up to the gas pump and get anything from E0 to E85 and their chance of misfueling their boat is what's critical. So when it gets down to one choice, they obviously have to pick the one fuel. So our concern——

Mr. GRAYSON. So if the renewable fuel standards were—could be in effect, then you wouldn't have that problem anymore, right?

Mr. REID. The challenge is is the variability of the fuel. You know, there's more than enough capability in the marine industry and different industries to dial in the engines to the fuel. The key thing is the legacy fleet that's out there is another part of that equation. We can produce going forward just like a number of industries changed to adapt to the local fuel or the consistent fuel.

Mr. GRAYSON. Right. And it's probably better to start now than start later; that just makes the problem worse, right?

Mr. REID. The issue——

Mr. GRAYSON. But let me give somebody else a chance. Mr. Red, is there any reason why Brazil can do it and the United States can't?

Mr. RED. I can't think of it technology-wise if, you know——

Mr. GRAYSON. They're not super geniuses? They have no special laws of physics in Brazil, nothing like that?

Mr. RED. It's probably worth another look.

Mr. GRAYSON. All right. What about you, Dr. Hill? Any reason why Brazil can do it, has been doing it for the past 80 years, and we can't?

Mr. HILL. So there have actually been some recent studies that have shown that the increased use of ethanol in Brazil has worsened their air quality.

Mr. GRAYSON. Ah. Well, we'll get to that shortly but you have to answer my question. My question is is there any reason why Brazil can have an E25 standard for 20 years now and the United States can't?

Mr. HILL. I'm not an expert on engine technologies, but I do know Brazil, even though they have 2/3 the population of the United States, uses I believe about a tenth of the fuel that we use——

Mr. GRAYSON. Sounds good to me.

Mr. HILL. —overall so the——

Mr. GRAYSON. Dr. Hill, now that we're on your subject here, are you aware of scholarly work, research in the industry that actually contradicts your conclusions?

Mr. HILL. No, I am not.

Mr. GRAYSON. Okay. Well, let's talk about that. The Renewable Fuel Association has been critical of your perspective on—oh, now you're nodding so maybe you are aware of this.

Mr. HILL. That's not—they don't do research.

Mr. GRAYSON. But let's answer my question, okay? In 2014 they released an analysis that raised questions about your paper—I see you nodding again—saying your conclusions "stand at odds"—I'm quoting now—"with real-world data showing decreases in ozone and PM2.5 concentrations" and that there's a "substantial body of evidence"—I see you nodding some more—"proving that ethanol reduces both exhaust hydrocarbons and carbon monoxide emissions and thus can help to reduce the formation of ground-level ozone." Now this rings a bell?

Mr. HILL. Well, I was always aware of that but I did not consider that in any way scholarly research. I'm happy to answer both of those points. So the first one, correlation——

Mr. GRAYSON. Let's start with my question. My question is isn't it fair to say that these studies contradict your conclusions?

Mr. HILL. Those are not studies. They—it is simply—that is——

Mr. GRAYSON. Results——

Mr. HILL. Renewable——

Mr. GRAYSON. What do you want to call them?

Mr. HILL. Renewable Fuel——

Mr. GRAYSON. I mean now you're quibbling, aren't you?

Mr. HILL. No, no, no. Renewable Fuel Association is a lobbying group so what they did is they showed—and I'm very aware of their—what they put out in relation to our work—they——

Mr. GRAYSON. Well, let's talk about——

Mr. HILL. They conflated the—okay.

Mr. GRAYSON. I have to interrupt you because time is short here. The Department of Energy has a model. You agree with me——

Mr. HILL. Yes.

Mr. GRAYSON. —the Department of Energy is not a lobbying group—that is considered to be very good for lifecycle emissions analysis and it highlights that the most recent model from the Department of Energy shows no increase in PM2.5 emissions or other criteria pollutants when gasoline is ten percent corn ethanol. That's contradicting your study and that's the Department of Energy, a rather authoritative source——

Mr. HILL. We actually used——

Mr. GRAYSON. —isn't it?

Mr. HILL. —Department of Energy results in our study——

Mr. GRAYSON. Um-hum.

Mr. HILL. —to come up with our analysis. That is tailpipe emissions.

Mr. GRAYSON. Um-hum.

Mr. HILL. Lifecycle emissions for corn ethanol are higher than for gasoline when you look at the whole lifecycle. That's what my testimony was about. Regarding the other point, correlation doesn't not equal causation. Ozone and PM levels have dropped but that's been due to other interventions in our national infrastructure, not due to the increased use of ethanol.

Mr. GRAYSON. All right. Well, Mr. Chairman, I'm well aware of information that contradicts Dr. Hill's testimony. I'd like permission to put that in the record.

Chairman WEBER. Without objection.

[The information appears in Appendix II]

Chairman WEBER. Does the gentleman yield back?

Mr. GRAYSON. Yes, I do.

Chairman WEBER. Thank you.

Mr. Loudermilk, you're recognized.

Mr. LOUDERMILK. Thank you, Mr. Chairman. This is very intriguing.

May I add that there are some significant differences between the United States and Brazil, and I think one of those is called freedom and consumer choice, which I think is one of the reasons why we have far exceeded a lot of other countries like Brazil and in fact that's what our founders envisioned in this nation was to let the people be ultimately in control of their choices.

I'm sure that as we study food products, as I'm often reminded in my home that my choices of food are probably not the best for my health. We could take the Brazil model with food and have the government dictate that we all eat a spinach salad every meal, but as——

Chairman WEBER. Let's not go too far now.

Mr. LOUDERMILK. —the American people—I don't think the American people are going to go that route.

Second of all, I was very intrigued in the answers that you weren't able to give and—because I'm very interested in facts here. I'm not trying to justify a wrong that may have already occurred. I would really like to hear what your response would have been to the gentleman from Florida if you were allowed to continue on with your response to the report—I may add—or define what the lobbying group came up with versus your research.

Mr. HILL. Thank you for the additional time to talk about this. We've long experienced interactions with the Renewable Fuel Association. In fact, one time they put out a report, a response to a previous paper of mine, that they actually copied 3/4 of it from something that had been published ten years earlier. So the—with regard to that particular response to our work in December, they put a graph that showed decreasing ozone levels and PM levels over time in the United States, and also showed increase in ozone levels. Well, you can also show all sorts of other correlations that exist. In fact, I encourage people to go to spuriouscorrelations.com. I believe if you Google it, it's on there. It shows ridiculous things, increasing levels of pirates and changes in dietary patterns, for instance. This is the same level of ridiculousness that was involved in this correlation that Renewable Fuel Association showed in that report.

So—and the other point is that the emissions of PM are very similar when you burn ethanol compared to gasoline. They might even be slightly lower in some cases. But that doesn't change all the emissions that occur as a result of producing the fuels. And in producing the fuels, the emissions are much higher for ethanol than they are for gasoline. So tailpipe, about the same. Producing the fuel is much higher for ethanol, in some much worse for ethanol than for gasoline.

Mr. LOUDERMILK. So put this in layman terms. You're looking at the lifecycle from when the corn seed is put in the ground to where it's burned and the emissions come out the tailpipe. The pollutants are greater in that entire lifecycle as compared to the entire lifecycle from when we drill and we extract the oil, we either import the oil or domestically refine it, until the emissions come out of the tailpipe. What I'm understanding you say is there are more air pollutants in that lifecycle with ethanol-based fuel than it is pure gasoline?

Mr. HILL. Ethanol from corn, yes, and for pollutants that affect fine particulate matter formation in the atmosphere and ozone formation, yes.

Mr. LOUDERMILK. Okay. To err is human, to forgive is divine, but the definition of insanity is once you err, you keep erring over and over and over again. We may have had a great idea with the renewable fuel standards. It sparked innovation to go down a path. Mr. Smorch, in your—the realm you're in is very interesting because I'm sure—and you can answer this—your suppliers benefitted financially from a renewable fuel standard because it created a market that didn't exist, is that true?

Mr. SMORCH. Our customers, yes. I mean we——

Mr. LOUDERMILK. Yeah.

Mr. SMORCH. —purchase oil and we refine it.

Mr. LOUDERMILK. Right. But to the point now because it hasn't gone the path that we expected it to go, it now is—you have a depleting market, is that right? You're being forced to produce something that you can't sell, at least in a percentage that your market demands?

Mr. SMORCH. Yes. We are comfortable with selling gasoline that has ten percent ethanol in it, but once you get the higher percentages of ethanol, it appears that the customer does not want that product.

Mr. LOUDERMILK. Okay. And, Dr. Hill, obviously you have no financial advantage one way or the other whether it produces a market or not. You're purely coming from just pure scientific research?

Mr. HILL. My work has not been sponsored by anybody except for federal competitive grants.

Mr. LOUDERMILK. Okay. This is very intriguing but I see that I'm out of time so, Mr. Chairman, I'll yield back.

Chairman WEBER. I thank the gentleman.

And the Chair recognizes the gentleman from California.

Mr. SWALWELL. Thank you, Chairman.

And just to clear the record and clear Brazil, it is neither a Third-World country or a dictatorship. Just didn't think we'd have to start the hearing clearing that up. But for Mr. Reid, Mr. Reid, do you agree that only about one percent of the fuel consumption in the United States is for recreational boats?

Mr. REID. I'm not aware of the data behind that. I'm really here to testify on the effects of E15.

Mr. SWALWELL. Okay. The data I'm familiar with is that in 2012 and every year since that, recreational boats consumed about 1.6 billion gallons of gas, which represents about one percent of the fuel consumption and that it's been pretty typical since then. So would you agree that, you know, to condemn an entire law or standard based on a population that is only one percent of fuel consumption may be going too far or perhaps throwing the baby out with the bathwater?

Mr. REID. Well, from my perspective, you know, the study was conducted on E15 to show there were detrimental results to that. I think the key thing there is we're looking at our legacy fleet that's recognized to be 40 years old. Of that, there's 12 million boaters—boats in the United States. So while it may be small in percentile, it's affecting many people.

Mr. SWALWELL. Sure. But most boaters would have the option of using E10, isn't that right? If they're at a fuel station, there's E15. There's supposed to be E10, which would not cause the problems you've described.

Mr. REID. Correct. E10 will not cause issues. Our engines are certified and validated on E10.

Mr. SWALWELL. So are you familiar with stations that are only serving E15 and not giving the E10 option to boaters?

Mr. REID. I'm not aware of the distribution of one particular fuel only at a gas station. I think there is a distribution of fuel, E0, E10, E15, E85. I think the key thing there is the education and knowledge when a person pulls up to the pump, are they selecting the proper grade? Are they grabbing a hose that's available? Are they looking at the price? That's not really my technical background or my background, but the key thing is that they select the correct one. Misfueling is definitely high potential.

Mr. SWALWELL. So you would agree, though, that maybe perhaps instead of changing the fuel standards an education campaign from your industry and perhaps even from government may also assist in correcting this issue?

Mr. REID. I'm not an expert in the social and the ability to educate consumers to that level of detail, but what I can tell you is E15 in boat engines will cause issues.

Mr. SWALWELL. Sure. Mr. Red, as we've—and thank you to each of you for appearing today. As we've heard today, one of the central concerns regarding ethanol blends is the blend wall concept and how to advance drop-in biofuels get over this purported hurdle? And if you could speak to how your company's work advances the prospective of integrating biofuels into the transportation fuel supply.

Mr. RED. Thank you. We have been working on this for nine years, and our focus from the very beginning was how can we do things without subsidies? How can we, you know, bring biofuels to a point where it can stand on its own, where it can contribute, you know, to lower greenhouse gas emissions, lower emissions, and some energy security to our country by not—and doing it without subsidies. Standing up a new technology, standing up new infrastructure against an industry that's been here for 100 years plus is challenging and an industry that controls the distribution and sale of fuels, you know, that is what we're up against with our technology. And so what our focus has been on taking low-cost feedstocks, converting them into 100 percent drop-in fuels and then providing that technology to folks who are interesting in making renewable fuels.

Mr. SWALWELL. And just a yes or no for each witness because there is not a representative here from the biofuels industry as far as the additives side, do you think it would have been more helpful to also hear from that perspective, Mr. Smorch?

Mr. SMORCH. I thought Mr. Red is from the biofuels.

Mr. SWALWELL. Well, he's on the drop-in side, right, Mr. Red?

Mr. RED. Yeah. We're not doing ethanol or biodiesel. We're doing 100 percent drop-ins that look and perform like petroleum.

Mr. SWALWELL. And there's a difference between drop-in and additive, right?

Mr. RED. One hundred percent drop-in fuel can be used without blending with petroleum and has the same performance or—you know, as petroleum so, you know, when you look at the additives, ethanol is not burned at 100 percent for a reason. You know, biodiesel is not burned at 100 percent for a reason. Our fuels are quite different from those.

Mr. SWALWELL. Do you think it would have been helpful, Dr. Hill, to hear from the ethanol industry?

Mr. HILL. Not at all.

Mr. SWALWELL. Okay. Hey, we appreciate honesty here. And, Mr. Reid?

Mr. REID. My perspective is based on our test data. If you, the Committee, needed to have that perspective, then that would have been beneficial. It's really up to you.

Mr. SWALWELL. Great. Thank you. And thank you to our witnesses, and I yield back.

Chairman WEBER. I thank the gentleman for yielding back. I recognize the gentleman from Kentucky, Mr. Massie.

Mr. MASSIE. Thank you, Mr. Chairman.

So in my district, consumers, at least anecdotally, are relating that they get less gas mileage from blended fuels than they do from petroleum that's not blended with ethanol. And what I want to clear up here today, because as recently as last week, a lobbyist for the ethanol industry tried to convince me that mileage was the same whether you had pure petroleum-based products or one that was blended with ethanol. So I'd like to ask each of the four of you, is the mileage the same with—from a gallon of gasoline versus a gallon of gasoline that's blended—been blended ten percent or 85 percent or 15 percent with ethanol? Mr. Smorch?

Mr. SMORCH. Ethanol only has about 67 percent of the energy content per gallon than a pure petroleum gasoline, so when you have a blended gasoline with gasoline and ethanol, the mileage will decrease as more ethanol is included in that blend.

Mr. MASSIE. And, Dr. Hill?

Mr. HILL. I'm not an expert in that area but it is a complicated question because you also have an oxygen boost with ethanol and so at some levels in some vehicle technologies it—you may have the same mileage, you may also have a drop in other cases. If you blend at high levels like E85, you will of course require more fuel to go the same distance but you'll also pay less at the pump.

Mr. MASSIE. Mr. Red.

Mr. RED. I'm not an expert in ethanol but I'll tell you our fuels will meet or exceed petroleum.

Mr. MASSIE. Mr. Reid?

Mr. REID. In the marine industry you will get worse fuel economy with E10.

Mr. MASSIE. And, Mr. Reid, you're the Director of Engine Design at Mercury Marine. I was hoping maybe you could explain to me—this is a little bit out of your field but related to engine design—why are the motorcyclists in my district so opposed to ethanol blends?

Mr. REID. I would only be speculating if I answered that question.

Mr. MASSIE. Well, please do in the context of their engines since you're Director of Engine Design.

Mr. REID. Well, I believe that's very similar to the prospective on the marine side. People I've seen on forums discussing with customers directly they will go to particular marinas that have what's called the REC–90. It's a 90 octane, zero ethanol fuel. I think they know—they have more comfort level with a zero ethanol fuel, that it'll burn, it'll have less likelihood of having interaction in their fuel system, less potential for water separation in their fuel system and the issues associated with that. I can only assume the motorcycle people think the same.

Mr. MASSIE. Mr. Smorch, again, I received some information from lobbyists last week that perhaps the reason ethanol wasn't selling well at the fuel stations was there was some sort of conspiracy among the oil and petroleum manufacturers and distributors that they didn't want to provide it to customers, yet I see signs in my district at the gas pumps that say "our gas is ethanol-free." Now, that seems to be a consumer question that comes up. Can you speak to consumer demand for ethanol and whether this is a conspiracy of the petroleum retailers?

Mr. SMORCH. Well, I can speak to our experience. We're a supply co-operative, and what we do is we sell wholesale to our member companies and they're the ones that actually retail the product. We sell and we supply to them what they ask us to supply, whether it's gasoline with E10. We supply E85 to them. We supply E0 to them. So we're not conspiring to not allow ethanol or higher ethanol blends to be out in the marketplace. But when you look at the data that we have and our experience, higher ethanol blends like E85, they just do not sell as much as an E0 or an E10 would.

Mr. MASSIE. Thank you very much.

Dr. Hill, in your estimation should corn ethanol be classified as a "green" fuel given its environmental impact?

Mr. HILL. The only thing green about it is the plant that it comes from.

Mr. MASSIE. Now, your findings would seem to find some support in a study released last year that ozone levels in Brazil actually have increased as ethanol usage did. Is that true?

Mr. HILL. I will need to go back and review that if that study was released last year not, but I believe that studies have come out that have shown worsening air quality in Brazil as the use of ethanol increased.

Mr. MASSIE. And does the EPA's Regulatory Impact Analysis reach similar conclusions that you do? I understand that EPA's triennial review, in that, they also found diminished air quality, water quality, biodiversity, and a number of other environmental impacts as a result of increased corn ethanol increased.

Mr. HILL. I was on the review panel for the triennial review, and the triennial review said that biofuels could be produced in ways that are better than gasoline and it said that they could be produced in ways that are worse than gasoline. It didn't specify whether the fuels produced from RFS2 are necessarily better or worse than gasoline or diesel.

Mr. MASSIE. Thank you very much. I yield back.

Chairman WEBER. I thank the gentleman and recognize the gentleman from Colorado, Mr. Perlmutter.

Mr. PERLMUTTER. Thanks, Mr. Chair. And to the panel, thank you for being here today. I don't really have a dog in this fight. I represent the suburbs of Denver. And, you know, Mr. Massie asked some questions about gas mileage. I think from my point of view we've seen that blended fuels have a little less mileage per gallon than straight petroleum but I'm not coming at it so much from the emissions standpoint as just a menu of fuels to be available to Americans, whether it's a blended fuel or a straight replacement or electricity or hydrogen fusion. I mean all of these would have some impact on how you make an engine, right?

Mr. REID. Absolutely.

Mr. PERLMUTTER. I mean each kind of these fuels you may have to alter the engines. You guys would have to build it, whether it's boats or cars or motorcycles, right?

Mr. REID. Other than if they're classified as drop-in.

Mr. PERLMUTTER. Okay. So drop-in is what Mr. Red's company makes and that's just a complete replacement equal to equal?

Mr. REID. Correct.

Mr. PERLMUTTER. Or better in your estimation, sir, Mr. Red.

Mr. RED. Emissions-wise it certainly is.

Mr. PERLMUTTER. Okay. So, Dr. Hill, I would assume, as a scientist, you wouldn't have any opposition to the fact that we're looking for and this country is trying out different kinds of fuels, would you?

Mr. HILL. Trying out fuels is a wonderful thing but you need to look very carefully whether you go whole hog into them. And I'll give you an example of this. Right now, we produce about 15 billion gallons a year of ethanol. If we were to increase our fuel efficiency of our fleet by average by one mile per gallon, we do as much for reducing petroleum use as producing that 15 billion gallons of fuel. So the direction you want to go is fuel efficiency and conservation and electrification rather than necessarily trying out all these fuels over the whole fleet. For some applications like aerospace, yes, that is a good option to consider because we really don't have other options.

Mr. PERLMUTTER. And that's the point. We want to have options. You don't want to be so married or so wedded to a particular fuel that if in fact there's some kind of embargo, all of a sudden you're in trouble until we come up with something else. And so from my point of view I want to have a menu of opportunities.

I think politically there has been a push for corn-based types of fuels, and in Colorado we have some corn that's not a main product for us. I would think Minnesota probably has a pretty good corn crop.

Mr. HILL. A very healthy crop.

Mr. PERLMUTTER. You know, and Iowa and sort of the center of the country so there's been a lot of politics driving this, as well as potentially maybe some emissions help. You know, certainly having an additional type of fuel to keep us as independent as possible and not subject to, you know, some kind of dictator's whim someplace on the planet.

So do—you know, what I do have in my district is a National Renewable Energy lab, which is looking at cellulosic and all kinds of different fuels from the fusion we talked about to better ways to burn the gasoline to whatever. So, Mr. Smorch, I mean you don't have a problem with us as a general proposition—and I appreciate Dr. Hill's point of view. You don't want to go whole hog if you don't have to. You know, if—but you don't have a problem with us testing out different kinds of fuels, do you?

Mr. SMORCH. No. From a testing standpoint there's no problem with that, but when the realities of the marketplace and getting it to the end consumer, that is where the challenge is.

Mr. PERLMUTTER. So at the gas station, though, if we're providing different kinds of fuels, then you've got to come up with different kinds of gas pumps, right, or some type of delivery system for a particular type of fuel?

Mr. SMORCH. Correct.

Mr. PERLMUTTER. So if we're doing natural gas, we've got to have some kind of natural gas. If we're going to do electricity, somebody's got to have a good plug-in. Likewise, if we're doing E85, it's got to be a certain kind of mix. If we're doing a drop-in, and I don't know, Mr. Red, do you have pumps in Colorado that are your particular type of fuel?

Mr. RED. We are just moving to commercial scale. We have four licensees. Two of them are in engineering now and building full-scale commercial facilities, so we are not at commercial scale yet.

Mr. PERLMUTTER. Mr. Reid, I would expect that as ideas or these different fuels come up, your company, you know, plays with modifying its engines from time to time just to make sure you could do it if you had to?

Mr. REID. Through the DOE funding we've looked at the 15. We've done that study in addition to the isobutanol study with the U.S. Coast Guard. So as they firm up and have support, we will get involved to understand their effect on the engine and then deal with the data that is supported within that study.

Mr. PERLMUTTER. Okay. Thank you. And thanks, Mr. Chair. I'll yield back.

Chairman WEBER. I thank the gentleman.

Mr. Knight, you are recognized for five minutes.

Mr. KNIGHT. I appreciate the stop in the Brazil back and forth, Mr. Perlmutter. Thank you for doing that because I was going to not make a Brazil comment so that we could stop on that.

Mr. Smorch, I'd like a couple answers. A couple of the questions that went back and forth were on what the customer wants, and I think one of the last questions was testing is okay. Give me an idea on testing on new petroleum, new ways of fueling our cars is okay, but when the government gets involved and says now we've got to do this; we are going to push this type of fuel source, give us an idea of the difference there between testing new fuels and actually making the customer have that choice or making the customer do this.

Mr. SMORCH. I mean doing—CountryMark is not involved with doing a lot of research and development on fuels, but going in—for independent people to go and find a different fuel source, that's fine. The reality of it is is that when you put in—just take gasoline. Gasoline is—everybody thinks that it's gasoline and ethanol. Really there's 30 different things that go into gasoline. It's a complex recipe. And what we do as refiners is we're trying to optimize what that recipe looks like. So if there's other economical streams that could get into gasoline, that'd be great because we—that's what we're trying to do to be able to provide the customer the best fuel and do it economically.

Mr. KNIGHT. Okay. So now let me go to Mr. Reid. You showed us this study of 300 hours of these three different types of engines working with three different types of fuel sources. Can you give us an idea, did the test go any further to show that if I run these fuels for such a period of time and the engine does make it how much it's going to cost me to correct the engine problems, how much it's going to cost me to fix it over the life of the engine, those types of things? And whenever you buy a car, it'll give you that little number there that says the cost to run this car for a year and whatever that might be, $1,200 or something like that. Did you do any further testing on the engines?

Mr. REID. Well, with the engine that did survive the E15 study, the 99 horsepower, we did complete emissions and testing on that, performance testing. It did deteriorate from an emissions standpoint. So that testing was done. We did not look at the economics of—necessarily in depth of what it would cost to run that fuel versus a different fuel, add in repairs at the end, or purchasing a new engine. But I can tell you that the other two engines that had failed, catastrophically failed would have been a brand new engine. It would have been thousands of dollars to replace at that point in time.

Mr. KNIGHT. Okay. So safe to say that I would be getting less hours or less MPG—I guess it would be hours on a boat——

Mr. REID. Yes.

Mr. KNIGHT. —engine and it would cost me more because I would have to repair the engine?

Mr. REID. In the end, yes.

Mr. KNIGHT. Okay. Mr. Red, can you give me an idea on how—what the Navy is feeling about the new drop-in fuel?

Mr. RED. I think the Navy is excited about it. Secretary Mabus for the last several years has said, you know, 50 percent is great but I'm looking for 100 percent replacement. They're looking for it from a strategic energy security point of view. If they're cut off from petroleum fuels, then they have no ability to fight a war. And if a fuel requires blending with petroleum and you're cut off from petroleum, you know, you still can't use it. So I think that they've wanted the option of being able to blend at any rate they want to and that's why, you know, they're choosing to look at our fuel.

The performance is important, too. If you get a performance boost with our fuel on a combat radius on an F–18 that otherwise is kind of combat limited, not like a Tomcat that had a lot of fuel, an F–18 is kind of limited on fuel so the Navy needs as much combat radius, needs as much miles in that F–18 tank of fuel as they can get. So they're looking for fuels that are efficient. But, you know, I think that's the two reasons they're looking for it is, one, energy security. You know, this can be, you know, in plants built around the world. We're looking at a lot of licensees in a lot of places around the world where the Navy operates that can build these plants and other places and so the Navy wants to be able to buy these fuels in different places and, you know, blend them at any rate.

Mr. KNIGHT. Okay. And are the other services looking at this, too?

Mr. RED. The Navy is the lead dog on renewable fuels. The Air Force did a lot of work through—you know, for over the last seven or eight years but right now the Navy is leading the charge on renewable fuels and the Army and the Air Force are taking their results and looking at what they're going to do with those fuels. The Army is buying about 3,000 gallons of our fuel to test alongside looking at the Navy results and are going to use our fuel as well.

Mr. KNIGHT. Okay.

Mr. RED. So they're pretty much taking those results and are going to look at certifying it for their platforms.

Mr. KNIGHT. Very good. Thank you, Mr. Chair. I yield back.

Chairman WEBER. Thank you, Mr. Knight.

Mr. Lipinski, you're recognized for five minutes.

Mr. LIPINSKI. Thank you, Mr. Chairman.

We're at an interesting point in the development of ethanol capacity where second generation of ethanol plants using—cellulosic feedstock are starting to come online. I think it's a real exciting development as it demonstrates the successful technological development that can reduce our dependence on corn feedstock for fuel, can make beneficial economic use out of what was formerly corn and agricultural waste and even trash and can develop fuel with even less environmental consequences than corn ethanol. Other advanced biofuels are also starting to come online and hold promise, so I think this is something we should all be celebrating.

However, we only have three such plants online right now. They're seeking financial commitments for future development depends on smart RFS policy and market signals that encourage investment.

Dr. Hill, in your testimony you note the potential environmental benefits of cellulosic ethanol over corn ethanol, as well as gasoline. So we'll start with Dr. Hill. Anyone else can join in here. How do you think we arrive at a point where more second generation capacity can be invested in and developed, moving us beyond corn ethanol and how do you see cellulosic ethanol and other advanced biofuels competitively moving ahead if the current RFS is held up?

Mr. HILL. So RFS to date has largely been satisfied by corn and soy, and to move to next-generation sources we need to look not only at RFS and of course very strong market signals that it can provide, but we even need to look into ag policy. You know, it'd be interesting to talk about that at some point. And we right now have very strong signals and support for the growth of annual row crops, corn and soy, such as subsidies for insurance. No such subsidies exist for many of these second-generation fuel feedstocks such as cellulosic sources like switchgrass, miscanthus and others that could produce fuels potentially better than our current conventional fuels. So one thing that would need to be largely changed would be to provide that sort of incentive to farmers to switch away from annual row crops to perennial crops that can provide much better lifecycle benefits than first-generation fuels.

Mr. LIPINSKI. Anyone else have anything? If not, I'll move on to Mr. Reid. Now, I understand the—as you discuss the challenges of using certain ethanol blends in smaller engines such as boats and motorcycles. However, it's my understanding that most everywhere that any ethanol blend is sold is also—there will also be E10 fuels available that are not injurious to boat or other small engines. So I'm trying to understand the marine industry's concerns about ethanol and RFS is safe gasoline options are widely available. Am I wrong that E10 is widely available or are there marinas or gas stations that are selling—only selling E15 or above blends? Can you explain more your concerns about safe fuel availability?

Mr. REID. It really comes down to if the consumers are given choices at the pump, with many pumps not clearly identified, our concern is that, and the data shows, that if they do run E15, it will be detrimental to their engine life, in addition to their boat fuel systems. So it's really outside my wheelhouse of talking about the market and how to ensure that they don't do this, but the effects if they do have a mistake are very detrimental.

Mr. LIPINSKI. So might this be more of an education issue rather than a matter of the RFS?

Mr. REID. I believe the National Marine Manufacturers Association would be better prepared to discuss that and they could provide you information on that. That's really not my expertise.

Mr. LIPINSKI. Okay. It just seems to me that it's not a situation where it's not available; it's that mistakes could be made in using the wrong fuel. And I understand the problems that that causes, but I think that maybe that's more of the issue, education, making clearer at the pumps what is available there, what everything is rather than the RFS. Thank you very much. I'll yield back.

Chairman WEBER. Thank you, Mr. Lipinski.

Bill Posey out of Florida is recognized for five minutes.

Mr. POSEY. Thank you, Mr. Chairman. And thank you for holding this hearing and bringing these great witnesses in here. And I hope if we have any more, we also might have representatives from some organizations that represent literally the concerns of millions of other Americans. And I'm talking about SEMA, the Specialty Equipment Marketing Association; the AMA, the American Motorcycle Association; the Antique Automobile Club of America; and many other groups that have had their members suffer since the introduction of corn into their gas tanks.

I'd like to ask each member of the panel just their opinion, yes or no if you could, if you agree with this statement: "The greater the amount of ethanol added to gasoline, the less efficient the gasoline is."

Mr. SMORCH. As I said earlier, as you add more ethanol into gasoline, the energy content does decrease.

Mr. POSEY. So that's a yes?

Mr. SMORCH. So yes.

Mr. POSEY. Yeah. We—one word.

Mr. HILL. I cannot do it in one word.

Mr. POSEY. You can't—so you—all right. That's——

Mr. HILL. It may or may not affect fuel economy. It depends on the technology that's used to——

Mr. POSEY. I didn't talk about fuel economy. I talked about efficiency.

Mr. HILL. Efficiency is a function of the fuel and the technology——

Mr. POSEY. Yes.

Mr. HILL. —that burns it.

Mr. POSEY. Basically, the more corn you stick in gasoline, the less efficient it is?

Mr. HILL. That is not necessarily so.

Mr. POSEY. Okay. Next?

Mr. RED. I'm not qualified to answer that one. That's not my expertise.

Mr. REID. In the marine engines, yes.

Mr. POSEY. Okay. Agree with this statement, yes or no, there are more pollutants in the total lifecycle of ethanol than gasoline?

Mr. SMORCH. I'm not qualified to answer that one.

Mr. HILL. There are many pollutants. For the ones that affect air quality and climate change, yes.

Mr. RED. That's not my expertise.

Mr. REID. I'm not qualified to answer that question.

Mr. POSEY. Okay. In your testimony, Mr. Reid, you outlined the research conducted by Mercury Marine in partnership with the National Renewable Energy Lab. Can you summarize the conclusions of that research on the impact of broad use of E15?

Mr. REID. Broad use of E15 will be detrimental to our customers' engines from the standpoint of, as I showed in the pictures, long-term durability issues. We showed increased temperatures in addition to compatibility issues with the fuel system. That could lead to leaks in addition to the boat. And the key thing there is our legacy fleet is 40 years old. Some of those fuels were designed and developed on leaded fuel, some of those engines. So we could see that they're going to be highly challenged by going to higher ethanol blends.

Mr. POSEY. And destroy the seals in every carburetor.

Mr. REID. Their incapability, we will find those, yes.

Mr. POSEY. Okay. What were the impacts of E15 on durability, emissions, and run quality, bottom line?

Mr. REID. It was deteriorated. They were worse with the E15 than E0 gasoline.

Mr. POSEY. Okay. And what is the impact of midlevel ethanol blends on marine engine performance?

Mr. REID. Could you define midlevel?

Mr. POSEY. Yeah.

Mr. REID. E10 plus?

Mr. POSEY. Yes, E10 plus.

Mr. REID. E10 plus will be similar results to our E15. It'll just be accelerated. The failures will occur faster if it's above E15 than what was shown in our study.

Mr. POSEY. Okay. And any thoughts about the human safety, environmental, and technological concerns associated with ethanol blends over ten percent in recreational boat fuel tanks and engines?

Mr. REID. I think the key thing is when you get stranded out on open water, be it a very large lake or the ocean, there is no tow truck that can come get you. It's a challenge and it's fearful. That's why our boating community has twins or at least two engines on the back of their boat, redundant systems similar to an airplane, so when they do go offshore, they can get back. So our concerns would be around people getting stranded and that potential risk, in addition to, as I outlined in my testimony, older fuel system in the boats were not certified for anything above E10.

Mr. POSEY. Okay. And what are the potential impacts of widespread sales of E15 on the boating industry?

Mr. REID. From the standpoint the data supports that the engines will be at risk from a durability standpoint. I can't tell you if those people that lose engines, that their engines fail are going to turn around and buy new products or they're going to get out of boating. One thing about boating is that it can be challenging at times to get to the water and enjoy the day, and we certainly don't want our consumers turning around say that's not right; that's not where I want to spend my time; I'm going to go elsewhere.

So we work very hard in the marine industry to make boating very easy. We add additional technologies. We're required to help the boater out to have an enjoyable day so that when they're on the water with their family, it turns out to be an excellent day.

Mr. POSEY. Thank you.

Chairman WEBER. I thank the gentleman.

With Mr. Perlmutter's permission, we're going to go for a second round to violate these witness' rights.

Mr. PERLMUTTER. This is not right.

Chairman WEBER. The Chair now recognizes Mr. Grayson from Florida.

Mr. GRAYSON. You have the right to remain silent. Anything that you say can and will be used against you. I'm talking to you, Dr. Hill.

Dr. Hill, has the renewable fuel standard increased or decreased carbon dioxide emissions?

Mr. HILL. The renewable fuel standard has increased net greenhouse gas emissions.

Mr. GRAYSON. Increased on a lifecycle basis?

Mr. HILL. Yes, it has.

Mr. GRAYSON. But not on a sort of spot basis if you will, not in terms of what's coming out of the tailpipe?

Mr. HILL. In terms of the—you can't look just in terms of the tailpipe in terms of the impact of those fuels.

Mr. GRAYSON. Well, you could; you just don't want to.

Mr. HILL. You could.

Mr. GRAYSON. Let's be honest.

Mr. HILL. You would be missing the point.

Mr. GRAYSON. All right. And this conclusion that you've reached, that refers only to corn-based ethanol, correct?

Mr. HILL. Actually, it's a bigger problem than that. So some recent work has come out that has looked at the fuel market rebound effect of these fuels. And so when you add more fuels into the system, essentially you mandate the addition of production of renewable fuels, you increase overall fuel use. And the lastest work that has come out has shown that using—producing an additional gallon of biofuel only reduces use of conventional fuels by about half-a-gallon. So you have to be much better off in terms of net greenhouse gas emissions to reduce overall greenhouse gas emissions. In fact, you have to be 50 percent better as a renewable fuel than gasoline to even break even in terms of net greenhouse gas emissions.

Mr. GRAYSON. All right. But the studies that you've done personally, they're based upon corn-based ethanol, correct?

Mr. HILL. We've done corn ethanol, we've done cellulosic ethanol from switchgrass, from stover, from many other feedstocks as well.

Mr. GRAYSON. Have you done sugarcane?

Mr. HILL. We have not done sugarcane.

Mr. GRAYSON. All right. What about the fuel that Mr. Red referred to? You haven't done anything on that, right?

Mr. HILL. He has a drop-in fuel, and the conversion process is very efficient but it requires feedstocks. It requires some sort of oil feedstock. And he can speak more about the requirements for those feedstocks. And as I described in my testimony, many of the impacts occur in the production of the feedstocks, not in the conversion or even the tailpipe. And so what the net greenhouse gas impacts of his fuels will depend largely on what happens in producing those feedstocks, as well as the fuel market rebound effects in terms of consumer use of these fuels.

Mr. GRAYSON. And Mr. Red also referred to the possibility of algae-based ethanol and so on. You've done no studies on algae-based ethanol, have you?

Mr. HILL. Actually, we have. We published a major study in Environmental Science and Technology last—I believe it was last September where we looked at algal feedstocks from a number of different sources using a number of different technologies evaluated over a number of different environmental impacts. And we showed that the only way that you'll have algal feedstocks that will be better than current fuel options is when you tie them to wastewater treatment processes. You essentially can clean up the water at the same time as you're producing algal fuels. Now, they may be incredibly expensive to produce but they could potentially be better if done in the right way.

Mr. GRAYSON. In general, all that we've been discussing, all these different options, they could be done in the right way, right? There's no natural barrier to having a biofuel that is—that produces less greenhouse gases than the alternative, which is fossil fuels, right?

Mr. HILL. You can do it but it may be incredibly expensive and your dollar may be much better spent if you're looking to reduce environmental impacts, as we all are, to go for efficiency or conservation or simply pay people to drive less. That would be a better option than some of these fuels.

Mr. GRAYSON. Mr. Red, give us some idea of the future of ethanol as you see it. How will ethanol be produced five years from now, ten years from now, 20 years from now? How will it be produced? From what?

Mr. RED. The future of ethanol or——

Mr. GRAYSON. Yeah.

Mr. RED. —other alternative fuels?

Mr. GRAYSON. Well, let's start with ethanol.

Mr. RED. I think, you know, there are several ways of doing it. They do it from algae. There are algal processes that produce ethanol. There's cellulosic technology and they're commercialized and they're doing it cellulosically from different cellulosic feedstocks. And then there's traditional corn that I think will be around for a while due to the political nature of this country.

Mr. GRAYSON. And what about alternative fuels more generally for transportation purposes only because that's what we're talking about today?

Mr. RED. The other alternative fuels?

Mr. GRAYSON. Yes.

Mr. RED. I think there's been a big shift towards how can we take waste feedstocks that are not used efficiently now, how can we turn those into great fuels? Brown grease, it's land-applied. It's—goes into landfills, it goes into water treatment. It's a—you know, people are trying to get rid of it. If we can take that and turn that into 100 percent drop-in diesel and jet fuel, that's a big win. Taking used cooking oil and turning that—you know, there are lots of different feedstocks out there that we can turn into, so it's a matter of finding these different streams of feedstocks and turning them into—efficiently into 100 percent drop-in fuels for us.

But we're not the only ones. You know, ARA and Chevron Lummus Global are doing it but Shell Environs are doing it. There are a bunch of other second-generation companies that are based on the RFS and the supports of the RFS going out there and introducing new technologies to take different feedstocks and efficiently turn them in—and it's all based on the efficiency, the greenhouse gas emissions and reductions in greenhouse gas emissions. You know, nobody's going to—nobody's going after first-generation, you know, 10 or 20 percent better than petroleum. Most—or if what he's saying is right, you know, a negative, most everybody's going after a 50 to 80, 90 percent reduction in greenhouse gas emissions. That's what second generation is looking for.

Mr. GRAYSON. Thank you.

Chairman WEBER. I thank the gentleman for yielding back.

And the Chair recognizes himself. Mr. Red, y'all produced jet fuel for the Navy and you may be interested to know that in our district there in Texas on the Gulf Coast my district produces 60 percent of the nation's jet fuel, obviously from a bit more traditional sources. When was—what's your cost as compared to regular what we would say conventional jet fuel?

Mr. RED. On a commercial scale we're going to be very competitive and 80 percent of it is going to be the cost of the feedstock. If you start with a brown grease, you're at 10 cents a pound, 80 cents a gallon. That's pretty competitive going against, you know, petroleum even below 50 bucks a barrel. So if 80 percent of our cost is feedstocks, commercially we're going to be very competitive. Our conversion technology is competitive with petroleum refining.

Chairman WEBER. All right. Let's put that into dollars and cents for us laypeople. So if a gallon of jet fuel is three bucks, what's you all's cost?

Mr. RED. At commercial scale with waste feedstocks, it'll be cost-competitive. It'll be right there at the cost of petroleum——

Chairman WEBER. So that's your aim but that's somewhere down the road quite a ways yet?

Mr. RED. Certainly. Certainly.

Chairman WEBER. Okay.

Mr. RED. That's at commercial scale.

Chairman WEBER. Okay. Let's go back to algae. Algal biofuel, when I was in the Texas Legislature I was on the Environmental Reg Committee and a member of the Energy Council, was 11 energy-producing States, four Canadian provinces, and that other country Venezuela, and we met around the country. And we'd had discussions about best energy practices and legislation and so on and so forth. We were talking about algal—we had somebody come in and talk to us about algal fuel, and the Canadian Minister of Energy—I think I've got his title correct—said it would never work in Canada.

And, Mr. Smorch, you kind of refer to the cold part of the year here because in Canada the weather was so severe most of the time that they couldn't grow enough algae for it to be cost-efficient. So they hadn't figured out how to grow enough of it because of the climate, and somebody popped up in the back and said if you'll make it illegal, the marijuana growers will figure out how to grow it.

But, Mr. Smorch, you actually mentioned this as being part of—in your testimony that even in your district—in your area I should say, how many months was it unrealistic to use the 15 percent or was it the 85 percent?

Mr. SMORCH. No. It was actually biodiesel.

Chairman WEBER. Right. Oh, the biodiesel.

Mr. SMORCH. And—yeah, it was in the biodiesel and it was in my written testimony. It was that just the way biodiesel is, it'll start gelling at 35 degrees Fahrenheit.

Chairman WEBER. So that's a pretty substantial——

Mr. SMORCH. Right. So——

Chairman WEBER. —portion or your winter.

Mr. SMORCH. So our members will not buy biodiesel from November through the middle of March, April 1st. They just won't—they won't buy it in their diesel fuel.

Chairman WEBER. Wow. Okay. Continuing with you, Mr. Smorch, the EPA has indicated that the sale of E0 will eventually cease as refiners work to comply with the RFS. Now, your website, CountryMark's website shows that you have 16 stations currently offering E0 within a 100-mile radius of Indianapolis. So if the refining of E0 eventually ceases, what does that do to those operations?

Mr. SMORCH. I know that the EPA probably says that E0 has to go to nothing but I think in our marketplace where it's available, the customer is going to demand that E0 is there. And so we'll—we will continue to supply it to our members.

Chairman WEBER. Okay. Let's jump over to you, Mr. Reid. I told you my dad had a gas station. He had boat sheds and I've seen those Evinrudes. I know that's a bad term—bad word around y'all, Mercury's and others, where they would fill up their boats and they'd go out. And y'all may know this and you may not. So you tested your engines for 300 hours on your boat motors. What is the average boater—I'm assuming they use their boat on the weekends. Do you have an hour number? Are they out—do they run that motor five hours a weekend, ten hours a weekend?

Mr. REID. It's typically that an average customer in the United States will run their boat less than 50 hours a year. But the key thing there is that same boat engine will also go to government sales, it'll go to taxi fleets——

Chairman WEBER. Sure.

Mr. REID. —so our distribution of hours per year is profound.

Chairman WEBER. Fifty hours a year, typical customer, okay.

Dr. Hill, you keep talking about switchgrass and this kind of is interesting to me. There's talk about cellulosic and that would be the grass and the yard clippings and so on and so forth. Switchgrass is not just a—is that the grass you just growing up along the highways? What is switchgrass?

Mr. HILL. You do in some areas. So switchgrass is a native perennial grass to much of the Midwest and eastern United States.

Chairman WEBER. Okay.

Mr. HILL. You'll see it in common prairie——

Chairman WEBER. Is it the same type of prairie grass—my dad also was in the hay business before he started his gas station business. Is it the same kind of prairie grass that we bale and feed the cattle?

Mr. HILL. It may have been. It depends on where your farm was. But switchgrass is one of the major components of the typical American prairie, a big blue stem, little blue stem, switchgrass and others. So it is a native plant and there's been a lot of interest in using it as a feedstock. I'm involved with a group called CenUSA.

It's a $25 million grant from the USDA specifically to look at the production of fuels from switchgrass.

Chairman WEBER. So in that instance you would say that those hay balers who make hay now for stock, whether it's horses or cattle or whatever, in some instances may change from baling hay to supply the cattle industry as it were to now the fuel industry if that becomes a widespread practice?

Mr. HILL. It's really no different. We've baled hay for many, many years, many, many centuries, if not millennia, and so using what we've learned in that production for biofuels has a lot of potential. You can produce switchgrass in ways that's better and you can produce it in ways that's worse.

Chairman WEBER. Okay.

Mr. HILL. You have to look at those practices that actually lead to good environmental benefits.

Chairman WEBER. Okay. Well, I appreciate that. And, Mr. Grayson?

Mr. GRAYSON. No further questions.

Chairman WEBER. No further questions for the witnesses, Your Honor. Okay.

Well, listen, we certainly thank you all for coming today to testify. And this concludes—actually, what I want to say is the record will remain open for two weeks for additional comments and written questions from the Members.

So this hearing is adjourned.

[Whereupon, at 11:43 a.m., the Subcommittees were adjourned.]

Appendix I

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Jason Hill

Response to questions for the record by

Jason Hill, Ph.D.
Associate Professor
Bioproducts and Biosystems Engineering
University of Minnesota

for the

Subcommittee on Energy
Subcommittee on Oversight
Committee on Science, Space, and Technology
United States House of Representatives

on

The EPA Renewable Fuel Standard Mandate

July 23, 2015

Chairman Smith, I offer my response to your question for the record:

> "**Questions for Dr. Jason Hill:** During the hearing, you were presented with several critiques of your research by minority members, including articles written by the Minnesota Biofuels Association, Growth Energy, and the Renewable Fuels Association. Please review the attached documents produced by the organizations listed above regarding your research. Can you respond to the specific critiques leveled by each organization?"

To facilitate the reading of my responses, I have copied below the entire text, unedited, of each of the three critiques of my research. My response to each point of each critique is in bold, indented text.

Response to RENEWABLE FUELS ASSOCIATION (RFA)

A recent paper by researchers at the University of Minnesota suggests that using corn ethanol in lieu of gasoline would increase emissions of fine particulate matter (PM2.5) and ground-level ozone. The results are based on numerous assumptions (many of which are unclear or concealed from the reader) and a series of complex hypothetical modeling scenarios.

> **All of our results and assumptions are publicly available and are not concealed from the reader.[1] In fact, we paid an extra fee for an "open access" option so that our article would be made free to download by anyone, including those not subscribed to the *Proceedings of the National Academy of Sciences.* The modeling approach we took was described in detail; others can replicate our results if they wish to do so.**

Ultimately, the authors' conclusions stand at odds with real-world data showing decreases in ozone and PM2.5 concentrations during the period in which ethanol blending substantially increased in the United States.

> **The RFA text confuses correlation with causation. Air pollution improved during 2000–2013, which were the years during which ethanol use increased most rapidly, but during that time there were also many other changes in our economy, including major environmental regulations impacting power generation, industry, and motor vehicles.[2] Indeed, it is quite possible that air pollution during 2000–2013 improved *despite* the increase in ethanol use, not *because* of it.**

The findings also run counter to an existing body of research that shows ethanol reduces PM2.5 and emissions that contribute to the formation of urban ozone, including exhaust hydrocarbons and carbon monoxide (CO).

> **We are unaware of research showing that the production and use of corn ethanol reduces overall concentrations of $PM_{2.5}$ and ozone. We note that it is important to evaluate fuels in terms of their life cycle impacts to air pollution, not just their effects on tailpipe emissions.**

Further, the paper is contradicted by the results of the Department of Energy's latest GREET model.

> **Our approach uses GREET; it does not contradict GREET.**

Finally, the study omits important emissions sources from the petroleum and electric vehicle lifecycle, resulting in a "stacked deck" against ethanol.

> **We in no way stacked the deck against ethanol. We applied consistent assumptions across fuel production and use pathways, deviating from default GREET assumptions only where explicitly noted in our report, with the goal of rigorously evaluating all fuel options.**

THE STUDY'S CONCLUSIONS ARE UNDERMINED BY REAL-WORLD OZONE AND PM2.5 TRENDS

The paper's assertion that increased ethanol use would cause higher emissions of ozone and PM2.5 is contradicted by EPA data from actual air sensors. Data from 222 EPA sensing sites show that ozone and PM2.5 concentrations have trended downward during the period in which the use of ethanol-blended gasoline has dramatically increased. Ozone concentrations have fallen 33% since 1980, while PM2.5 is down 34% just since 2000. In recent years, both ground-level ozone and PM2.5 emissions have dropped below their respective national standards, according to EPA. Specific "non-attainment" areas where reformulated gasoline (RFG) is required have shown similar reductions since ethanol was introduced as an oxygenate.

> **The RFA text confuses correlation with causation. Air pollution improved during 2000–2013, which were the years during which ethanol use increased most rapidly, but during that time there were also many other changes in our economy, including major environmental regulations impacting power generation, industry, and motor vehicles. Indeed, it is quite possible that air pollution during 2000–2013 improved *despite* the increase in ethanol use, not *because* of it. With regard to the status of**

ethanol as an oxygenate, evaluation of the total impacts of ethanol requires consideration of the life cycle impacts to atmospheric pollutant concentrations, not just changes in tailpipe emissions.

THE STUDY'S FINDINGS ARE AT ODDS WITH EMISSIONS ESTIMATES FROM THE LATEST GREET MODEL

On a full lifecycle basis (i.e., including the contributions of upstream agriculture emissions), the study's results are contradictory to the results from the Department of Energy's latest GREET model. This is particularly confusing because the authors claim to have used an earlier version of the GREET model for their analysis. It is unclear whether the authors adjusted key inputs in the GREET model, and on what scientific basis such adjustments might have been made.

RFA asserts that there are contradictions but fails to give examples. There is nothing specific in RFA's comment that we can address other than restating that we also used GREET; there are no contradictions between our work and GREET. We applied consistent assumptions across fuel production and use pathways, deviating from default GREET assumptions only where explicitly noted in our report, with the goal of rigorously evaluating all fuel options.

The most recent GREET model shows no increase in PM2.5 emissions or other criteria pollutants when gasoline with 10% corn ethanol is compared to conventional gasoline without ethanol.

The RFA statement is incorrect. GREET actually shows increased life cycle emissions of criteria pollutants with 10% corn ethanol gasoline blends as compared to gasoline without ethanol. Moreover, the RFA's statement fails to reflect that $PM_{2.5}$ can be emitted (primary $PM_{2.5}$) or formed (secondary $PM_{2.5}$). Consideration of the total impacts to $PM_{2.5}$ concentrations from fuels must account for emissions of primary $PM_{2.5}$ and also of $PM_{2.5}$ precursors such as VOCs, NO_x, SO_x, and NH_3.

Further, when E85 from corn ethanol is compared to conventional gasoline, GREET1_2014 shows that using E85 decreases urban emissions of volatile organic compounds (VOC), nitrous oxide (NOx), coarse particulates (PM10), fine particulates (PM2.5), and sulfur oxide (SOx).

The RFA statement mentions urban emissions but fails to mention rural emissions. For multiple pollutants, GREET shows decreased urban emissions but higher total life cycle emissions because of higher rural emissions. It is necessary to account for both urban and rural emissions, as our study does. People live in rural areas and in urban areas, and air pollution can travel from rural to urban areas, and vice versa. Our study accounts for the transport of air pollution in the atmosphere.

The high levels of PM2.5 and ozone concentration attributed to corn ethanol in the Minnesota study appear to be mostly related to assumed upstream agricultural practices, such as fertilizer application. However, the paper and the supporting material do not clarify what assumptions were used for fertilizer production and application, or other agricultural activities.

RFA is correct that agricultural emissions are important. All of the assumptions for fertilizer production, application, and other agricultural activities are provided in our

report and in its supporting material. Unless otherwise noted in our report, all of the assumptions used are those of the GREET model. Peer review by other experts in the field and by the editorial staff of the journal concluded that our methods and assumptions were sufficiently documented and justified.

Further, the study omits NOx and SOx emissions for other fuels if those emissions occur "far from population centers." Yet, it appears all NOx and SOx emissions associated with agricultural production of biofuel feedstocks are included even though most feedstock production occurs in sparsely populated rural areas.

The statement that our "study omits NOx and SOx emissions for other fuels if those emissions occur 'far from population centers'" is false. Within our modeling domain of the continental United States and surrounding waters, we account for all emissions occurring in both urban and rural areas. We exclude a fraction of life cycle pollutant emissions from our estimates of health impacts, as we show in Figure S2, but not because they are "far from population centers"; rather, it is because they are outside of our modeling domain (that is, outside of the continental United States and its surrounding waters). We state that their effect, which is largely over open oceans or far from population centers, is not likely to impact our overall conclusions. We treat ethanol the same as we do petroleum; we exclude emissions from international fertilizer production and transport, and we exclude emissions from international extraction and transport of petroleum used in ethanol production.

OTHER RESEARCH SHOWS ETHANOL REDUCES THE POTENTIAL FOR OZONE AND PM2.5

Urban ozone formation occurs from rather complex atmospheric photochemistry, as volatile organic compounds (VOC) and carbon monoxide (CO) react in the presence of nitrogen oxides (NOx). Both the EPA and National Research Council have recognized that CO is a precursor to ozone formation. There is a substantial body of evidence proving that ethanol reduces both exhaust hydrocarbons and CO emissions, and thus can help reduce the formation of ground-level ozone. Indeed, ethanol's high oxygen content and ability to reduce exhaust hydrocarbons and CO emissions is the primary reason it is used as an important component of reformulated gasoline in cities with high smog levels.

Further, research has shown that increasing the oxygen content in gasoline reduces primary exhaust particulate matter (PM2.5) from the tailpipe. Because ethanol is 35% oxygen by weight, blending ethanol with gasoline increases the oxygen content of the fuel and thus reduces PM2.5 emissions.

Ozone chemistry is complex, and our study accounts for this complexity. We accounted for all of the factors stated in this comment from RFA, but we note that while ethanol may decrease tailpipe emissions of some hydrocarbons, it may increase emissions of others. Furthermore, the argument presented by RFA above ignores emissions caused by fuel production. It is important to consider total life cycle impacts from air pollution, not just tailpipe emissions.

Our study uses emissions factors from the GREET model. We note that EPA has concluded that the use of ethanol as mandated by the Renewable Fuel Standard is likely to increase ozone concentrations over the United States by as much as 1 ppb.[3]

THE STUDY USES QUESTIONABLE ASSUMPTIONS REGARDING OTHER FUELS

The Minnesota study's lifecycle emissions estimates for electric vehicles (EVs) do not include emissions associates with battery production, a glaring omission that creates an inconsistent framework for comparing various fuel/vehicle options. The authors admit that emissions associated with battery production account for "about half" of total EV lifecycle emissions—yet those emissions are excluded from the central scenario.

This statement by RFA is simply false; our study does include battery production. Our article states this fact several times: in the introduction, materials and methods, results, and discussion sections. See, for example, Figure 2 on page 18492, where "$PM_{2.5}$ from battery production" is clearly labeled. We are unsure how RFA's close reading of our report could have missed this aspect of our work.

Contrary to RFA's assertion, we do not "admit that that emissions associated with battery production account for 'about half' of total EV lifecycle emissions." Rather, we state that about half of the emissions from battery production occur outside of our modeling domain (that is, they are international) and thus are excluded from the analysis. We test the sensitivity of our model runs to this assumption in a complementary analysis in which we double the impacts from battery production. As we describe in our paper (p. 18492), this modification does not change the relative impacts of any of the fuel options we considered.

The study also excludes NOx and SOx emissions associated with crude oil extraction, a decision that grossly underrepresents the actual lifecycle emissions impacts of gasoline. These emissions were excluded because the authors assume they occur outside the geographical boundaries of their study area. The authors also assumed all crude oil in 2020 is extracted using conventional methods, which entirely ignores the emissions impacts of unconventional extraction techniques. According to the paper, "oil extraction from oil sands occurs outside of our geographic modeling domain," and thus they assume "all oil is extracted conventionally (0% oil sands oil)."

Omitting key emissions sources from the lifecycle assessment of EVs and crude oil inappropriately skews the paper's results for the overall emissions impacts of these fuels and vehicles.

Again, this statement by RFA is false. We do not exclude NO_x and SO_x emissions associated with crude oil extraction and transportation, except for the fraction that occurs internationally, which is primarily over oceans or far from population centers. Our assumption concerning conventional extraction techniques is justified by the primary source of unconventional oil imported into the United States being Canadian oil sands, which themselves are in sparsely populated areas far from population centers. A similar simplifying assumption was made for ethanol, in which emissions from the production and transportation of imported fertilizers were likewise excluded.

Response to GROWTH ENERGY

Following the recent report released by the University of Minnesota, "Life Cycle Air Quality Impacts Of Conventional And Alternative Light-Duty Transportation In the United States," which contains significant flaws in regards to their analysis of ethanol, Tom Buis, CEO of Growth Energy, released the following statement:

"Clearly this study was published with an agenda and without regard to the facts. It is misleading, inaccurate and runs counter to a large body of expert research.

> **We reviewed other expert research in the preparation of our report. We conducted our own research objectively and without outside influence. Our funding was solely from competitive grants awarded from federal or state agencies. Our research underwent peer review in the *Proceedings of the National Academy of Sciences*. We are unaware of the "large body of expert research" to which our work runs counter; Growth Energy offers no support of their claim.**

"This report also fails to account for the numerous environmental benefits ethanol provides. According to Argonne National Laboratory, ethanol reduces greenhouse gas (GHG) emissions by an average of 34 percent compared to gasoline, even when the highly controversial and disputed theory on Indirect Land Use Change (ILUC) is factored into the modeling. However, the study by the University of Minnesota specifically excludes ILUC impacts, and Argonne has found that without ILUC included, ethanol reduces GHG emissions by 57 percent compared to gasoline.

> **Indirect land-use change is a widely accepted principle whereby increased demand for crops for biofuels leads to higher crop prices, which in turn leads to global expansion of cropping area. The values from Argonne National Laboratory cited by Growth Energy are among a wide range of estimates from various research groups that show higher or lower greenhouse gas emissions of corn ethanol compared to gasoline.[4] Furthermore, Argonne National Laboratory's estimates ignore the fuel market rebound effect, whereby additional ethanol production does not completely displace gasoline production, resulting in increased net greenhouse gas emissions.[5] Notably, EPA's own analysis of the Renewable Fuel Standard found that corn ethanol produced through at least the year 2017 has higher greenhouse gas emissions than gasoline, even without consideration of the fuel market rebound effect.**

"In fact, in 2013, the 13.2 billion gallons of ethanol blended into gasoline in the United States helped reduce GHG emissions by approximately 38 million metric tons, which is the equivalent of removing roughly 8 million automobiles from the road.

> **This claim is debatable for the reasons provided above. Even if it were to be the case, it does not address the new information added by our study, namely the increased health impacts caused by $PM_{2.5}$ air pollution from corn ethanol production and use relative to gasoline.**

"In addition, another critical component that was unsurprisingly left out of the University of Minnesota's report is that ethanol, with its high octane content, reduces the need to add toxic aromatics to gasoline to bolster octane and engine performance such as benzene and 1-3 butadiene that are known carcinogens. Additionally, ethanol plays a major role in reducing ultra-fine particulates in exhaust emissions that are linked to a large number of adverse health outcomes."

> **The overwhelmingly dominant environmental health impact of fuel choice is cardiovascular related mortality caused by exposure to atmospheric fine particulate matter ($PM_{2.5}$). Growth Energy's comments concern pollutants other than fine particulate matter that have relatively insignificant or less-proven health impacts. Thus, their comments do not affect our analysis of monetized health impacts.**
>
> **Growth Energy refers to ultrafine particulate matter, whereas we studied fine particulate matter. Despite these two pollutants having similar-sounding names, they are different. The epidemiological evidence regarding the health impacts of fine particulate matter is many-fold more robust than that of ultrafine particulate matter.**
>
> **Furthermore, Growth Energy does not provide evidence or citations for their assertions about ethanol reducing ultra-fine particulate matter. It also appears that they are referring to tailpipe emissions rather than to life cycle emissions. As our research demonstrated, comparisons of tailpipe-only emissions are incomplete and fail to account for non-tailpipe emissions from fuel production and for the transport and transformation of those emissions.**

Response to MINNESOTA BIO-FUELS ASSOCIATION

The recent report released by the University of Minnesota, "Life Cycle Air Quality Impacts Of Conventional And Alternative Light- Duty Transportation In the United States," contains several inaccuracies and misleading information.

In particular, its conclusion that corn-based ethanol contains more harmful pollutants than gasoline runs contrary to findings from the Argonne National Laboratory (which is a non-profit research laboratory operated by the University of Chicago for the U.S. Department of Energy), the U.S. EPA and the Energy Information Administration (EIA).

> **The Minnesota Bio-Fuels Association's statement is false. Our findings do not run contrary to the model from Argonne National Laboratory. In fact, we use their model, GREET, in our analysis. We note that the issue is not whether "corn-based ethanol contains more harmful pollutants than gasoline," but rather whether corn-based ethanol causes greater human health damage from air pollution than gasoline.**

The authors of the report state that corn-based ethanol emits more ozone and particulate matter than gasoline. Ozone is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) while particulate matter is an air pollution term for a mixture of solid particles and liquid droplets in the air.

> **The Minnesota Bio-Fuels Association's statement contains a minor error related to the *emission* versus the *formation* of a pollutant. As they mention, ozone is created in the atmosphere, not emitted. When the Minnesota Bio-Fuels Association summarizes our results, however, they say that we state that ozone is emitted. Their**

> **statement is false. We do not state that ozone is emitted; rather, we consistently describe it as being formed in the atmosphere.**

Both ozone and particulate matter can trigger health problems. While the U Of M's report states that these two pollutants increase with ethanol usage, data from the EPA suggests otherwise. According to the EPA, the amount of ozone in the air has decreased 18 percent from 2000 to 2013. In the Upper Midwest, ozone levels have fallen 11 percent during the same time period. Similarly, particulate matter has decreased 34 percent nationwide from 2000 to 2013. It is important to note that the drop in ozone and particulate matter coincide with the increase in ethanol blended gasoline which took off on a large scale after the implementation of the Renewable Fuel Standard in 2005.

> **The Minnesota Bio-Fuels Association's text confuses correlation with causation. Air pollution improved during 2000–2013, which were the years during which ethanol use increased most rapidly, but during that time there were also many other changes in our economy, including major environmental regulations impacting power generation, industry, and motor vehicles. Indeed, it is quite possible that air pollution during 2000–2013 improved *despite* the increase in ethanol use, not *because* of it.**

Moreover, the Argonne National Laboratory's GREET (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) model – which was also used by the authors of the report – shows total urban life cycle emissions of VOC, NOx and particulate matter in a vehicle using E10 (gasoline that contains 10 percent ethanol) is lower than in a vehicle using gasoline which contains no ethanol.

If compared with a vehicle running on E85 (gasoline that contains 85 percent ethanol), GREET shows that the urban emission reductions are even more significant at 5 percent (VOC), 7.8 percent (NOx) and 20 percent (particulate matter).

> **The values cited here by the Minnesota Bio-Fuels Association are for urban emissions only and ignore rural emissions. For multiple pollutants, GREET shows decreased urban emissions with E10 or E85 compared to E0, but GREET also shows higher total life cycle emissions of these pollutants because of higher rural emissions. It is necessary to account for both urban and rural emissions, as our study does. People live in rural areas and in urban areas, and air pollution can travel from rural to urban areas, and vice versa. Our study accounts for the transport of air pollution in the atmosphere.**

Interestingly, the report did not address CO2 emissions which dominates greenhouse gas emissions. According to the EIA, a gallon of gasoline that does not contain ethanol produces 19.64 lbs of CO2. A gallon of ethanol , on the other hand, emits 12.72 lbs of CO2.

As such, E10 produces 18.95 lbs of CO2 while E85 emits 13.75 lbs of CO2. Thus, it is quite clear that using ethanol reduces the level of CO2 in the air.

> **The Minnesota Bio-Fuels Association's statement that we did not address CO_2 emissions is false. We included a detailed analysis of greenhouse gas emissions from**

the fuel options we considered. See, for example, Figure 3 of our report, which includes a clear label for climate change impacts.

The estimates of greenhouse gas emissions that the Minnesota Bio-Fuels Association presents are misleading. They are tailpipe emissions of CO_2 from burning gasoline and ethanol,[6] not life cycle emissions; that is, they do not account for emissions released during the production of these fuels. Furthermore, presenting tailpipe emissions on a per gallon basis rather than on an energy-equivalent basis ignores the mileage penalty with ethanol, which is a result of ethanol being only about two-thirds as energy dense as gasoline; that is, vehicles burn more ethanol than gasoline to go the same distance.

In 2012, some 2.45 billion gallons of gasoline was consumed in Minnesota. If we assumed that all 2.45 billion gallons were E10, it would mean 766,571 metric tons of CO2 was prevented from being released into the air thanks to ethanol.

That, according the EPA's greenhouse gas equivalencies calculator, is the equivalent of removing 161,383 cars from the road for a year in Minnesota.

These calculations are incorrect. As stated above, they do not account for the emissions released during fuel production and for the lower energy density of ethanol.

Considering the above, it is clear that ethanol is a much cleaner fuel than gasoline. Moreover, it is important to note that the authors of the study did not factor emissions from Canadian oil sands in their analysis of life cycle emissions from gasoline. This in itself casts more doubts on their findings as 70 percent of oil imported from Canada (which would include oil sands from Alberta) are brought into the Midwest.

Alberta oil sands extraction was excluded because it occurs outside of our modeling domain of the continental United States and its surrounding waters. Furthermore, Alberta oil sands extraction occurs in sparsely populated, remote areas and is unlikely to cause health impacts that are sufficiently larger than conventional oil extraction health impacts to affect the results of our study. A similar simplifying assumption was made for ethanol, in which emissions from the production and transportation of imported fertilizers were likewise excluded.

Even if the Minnesota Bio-Fuels Association's calculations were correct, they are regarding greenhouse gases, which does not address the new information added by our study, namely the increased health impacts caused by $PM_{2.5}$ air pollution from corn ethanol production and use relative to gasoline.

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6. U.S. Energy Information Administration (2015) Frequently Asked Questions: How Much Carbon Dioxide Is Produced by Burning Gasoline and Diesel Fuel? Accessed at <www.eia.gov/tools/faqs/faq.cfm?id=307&t=11>.

Appendix II

ADDITIONAL MATERIAL FOR THE RECORD

PREPARED STATEMENT OF COMMITTEE RANKING MEMBER EDDIE BERNICE JOHSNON

Thank you Mr. Chairman and thank you to the witnesses for being here today. While I certainly appreciate your testimony, I must note that the panel today is not fully representative of the views on this topic. The Renewable Fuel Standard, or RFS, is a major policy enacted by Congress with complex implications for many businesses, the environment, and the economy as a whole.

Most importantly, we will not be hearing from either the EPA, the agency responsible for implementing the standard, or the Department of Energy, the lead agency for the federal government that conducts research into advanced biofuels.

There are real concerns about how the the RFS is being implemented, and we will need to hear from both EPA and DOE if we are to fulfill our oversight responsibilities.

It is fair to say that EPA has failed to implement the RFS for 2014 and 2015 in a timely fashion. This delay is due, in part, to the more than 300 thousand comments received on its original proposal in November 2013. According to EPA, these comments represented divergent views on a variety of topics such as the so-called "blendwall," the extent to which it should use its waiver authorities, and the intent of Congress.

While I am not condoning the delay, I do understand the need to evaluate these comments, and it underscores the importance of hearing from EPA on this topic.

While there may be differing views on how best to implement the RFS, it is clear to me that this policy is an important tool for reducing our dependence on fossil fuels, reducing our nation's greenhouse gas emissions, and encouraging innovation that is leading to the development of advanced, more sustainable alternative fuels.

In fact, on Monday, 36 Senators of both parties from 24 states sent a letter to Administrator McCarthy urging her to increase EPA's advanced biodiesel volume requirements for 2016 and 2017 to better reflect the state of a growing domestic biodiesel industry.

Mr. Chairman, the Renewable Fuel Standard is a complicated issue, and I hope that this hearing today is not the end of our discussions on this matter.

With that I yield back.

PREPARED STATEMENT OF SUBCOMMITTEE ON OVERSIGHT
RANKING MINORITY MEMBER DON BEYER

Thank you Chairmen Weber and Loudermilk for holding today's hearing and thank you to the witnesses for testifying.

The greatest challenge of this generation—climate change—requires innovative solutions if we ever hope to make a meaningful difference. It requires us to look at every aspect of our energy production and consumption. We must find ways to end our dependence on fossil fuels and reduce our greenhouse gas emissions.

The Renewable Fuel Standard has helped to push the technological limits and the capacity of industry to innovate our transportation fuels. In the past ten years we have seen increasing production of biofuels from both corn ethanol and advanced biofuels. This increase has come with considerable advancements in how corn ethanol is produced, improving production efficiencies while decreasing both costs and greenhouse gas emissions.

While there is much more to be done, I am hopeful for the potential in advanced biofuels. The Renewable Fuel Standard was designed to integrate all biofuels into our fuel supply and lay the groundwork for the growth and development of advanced biofuels with at least a 50% reduction in greenhouse gas emissions compared to that of conventional gasoline. I am interested in hearing more about the advancements in this area and where we can expect biofuels to be in the next ten years.

All of this does not go without saying that there have been challenges. The Environmental Protection Agency recently issued volumetric requirements for 2014, 2015, and 2016, after missing the statutory deadline two years in a row. While inundated with public comments during the proposal process, it does not excuse this lengthy delay. The agency has issued waivers for the required cellulosic biofuels and plans to do so again. I hope the proposed volumetric obligations can be finalized by the November 30th deadline.

With a wide ranging body of research looking at every aspect of production and a range of stakeholders that have advocated for almost every different scenario available, we as lawmakers are left with difficult decisions to make. I hope we can continue to educate ourselves with additional hearings in order to inform our decisions on America's energy future. In particular, I look forward to hearing from DOE and EPA on this topic.

Thank you Mr. Chairman.

PREPARED STATEMENT OF REPRESENTATIVE ZOE LOFGREN

On Thursday, July 23, the Committee on Science, Space, and Technology Subcommittees on Energy and Oversight held a joint hearing titled, "The EPA Renewable Fuel Standard Mandate" to discuss the economic and environmental impacts of the Renewable Fuel Standard (RFS). While I was unable to attend this hearing, it is important to examine the role renewable transportation fuels can play in addressing climate change and reducing our dependence on foreign oil.

The changing climate and our response to it are among the most important issues facing us today. I have long been a proponent of developing and deploying renewable energy sources. We cannot continue to rely on conventional liquid fuels because such dependency poses a risk to both our environment and our national security.

Commercializing new technologies is not easy or fast, but long-term policies like the RFS have been a critical driver in the accelerated development of second-generation biofuels. Low-carbon, second-generation advanced and cellulosic biofuels, and biomass-based diesel can provide cleaner, greener transportation fuel, and an alternative to more land use intensive forms of corn-based ethanol. In California, investing in advanced biofuels is vital for us to meet our long-term goals of a cleaner and domestically fueled transportation fleet.

It is unfortunate that the Science Committee held an oversight hearing without seeking input from the administering agency on the potential challenges and opportunities for improving the RFS. As the Environmental Protection Agency finalizes its RFS standards for 2014-2016, and as the Administration looks to secure an international agreement to address climate change, we must ensure that this policy is implemented in a way that provides certainty, supports continued investment in a burgeoning alternative fuels industry, and protects our economic and environmental interests.

DOCUMENTS SUBMITTED BY REPRESENTATIVE LOUDERMILK

August 6, 2015

The Honorable Barry Loudermilk
Chairman, Committee on Science, Space, and Technology, Subcommittee on Oversight
United States House of Representatives
238 Cannon House Office Building
Washington, DC 20515-1011

The Honorable Randy Weber
Chairman, Committee on Science, Space, and Technology, Subcommittee on Energy
United States House of Representatives
510 Cannon House Office Building
Washington, DC 20515-4314

Re: July 23, 2015 hearing, "The EPA Renewable Fuel Standard Mandate"

Dear Chairmen Loudermilk and Weber:

On behalf of the Specialty Equipment Market Association (SEMA), I thank you for holding the July 23rd joint subcommittee hearing on the Renewable Fuel Standard (RFS) and the consequences of increased use of E15 (gasoline that is 15 percent ethanol) on engines and transportation fuel distribution systems.

SEMA represents the $36 billion specialty automotive industry. Our trade association is comprised of 6,800 mostly small businesses nationwide that manufacture, distribute and retail specialty parts and accessories for motor vehicles. The industry employs over 1 million Americans and produces performance, functional, restoration and styling-enhancement products for use on passenger cars, trucks and special interest collector and historic vehicles, like the ones that will be most directly and immediately affected by a change in the ethanol content of gasoline.

While the 2005 law that established the RFS was designed to reduce U.S. dependence on foreign oil, it did not take into consideration the fact that ethanol can cause metal corrosion and dissolve certain plastics and rubbers, especially in older cars that were not constructed with ethanol-resistant materials. The RFS was updated in 2007, increasing the amount of biofuels to be blended into gas each year through 2022, while providing the U.S. Environmental Protection Agency (EPA) with the ability to reduce the renewable volume obligation (RVO). The EPA recently proposed reduced volume levels for 2014, 2015 and 2016. This is a clear indication that the EPA recognizes that the current marketplace cannot sustain increased levels of ethanol through sales of gasoline with 10 percent ethanol (E10), and that sales of E15 are limited.

Specialty Equipment Market Association (SEMA)
1317 F Street, NW; Suite 500; Washington, DC 20004
Telephone: 202/783-6007; Fax: 202/783-6024

SEMA opposes E15, contending that the fuel poses a risk to 74 million older vehicles in addition to certain specialty high performance equipment installed on newer vehicles. EPA's decision to limit E15 sales to model year 2001 and newer vehicles acknowledges the risks that higher blends of ethanol pose to older vehicles. However, the agency only requires a gas pump warning label making it "illegal" for the consumer to fuel older vehicles with E15. This is insufficient protection for many motorists who may mistakenly fill their older vehicles with E15.

The EPA has been placed in a difficult position seeking to achieve artificial RFS mandates that place consumers and their vehicles at risk. There is a solution. SEMA and a coalition of more than 50 other organizations from the auto, boat, food and energy industries support H.R. 704, the "RFS Reform Act of 2015," which caps the amount of ethanol blended into gasoline at 10% and eliminates the RFS's corn-based ethanol requirement. We respectfully urge Congress to pass the bill.

I thank the committee for reviewing the RFS's impact and for its efforts to ensure that meaningful reforms to the law are considered. Please feel free to contact me if you have any questions.

Sincerely,

Stephen B. McDonald
Vice President, Government Affairs
Specialty Equipment Market Association

DOCUMENTS SUBMITTED BY REPRESENTATIVE GRAYSON

RFA RENEWABLE FUELS ASSOCIATION

RESPONSE TO *PNAS* ARTICLE:

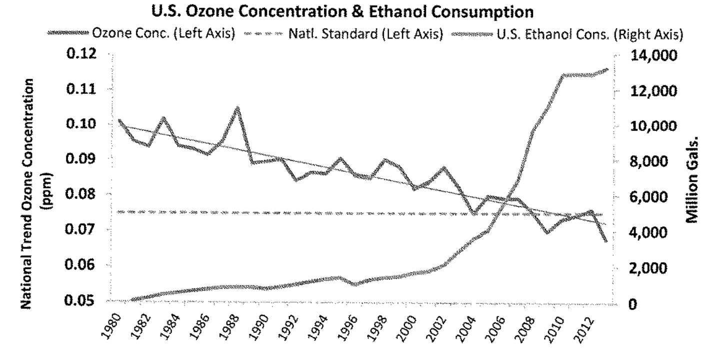
"LIFE CYCLE AIR QUALITY IMPACTS OF CONVENTIONAL AND ALTERNATIVE LIGHT-DUTY TRANSPORTATION IN THE UNITED STATES"

A recent paper by researchers at the University of Minnesota suggests that using corn ethanol in lieu of gasoline would increase emissions of fine particulate matter (PM2.5) and ground-level ozone.[1] The results are based on numerous assumptions (many of which are unclear or concealed from the reader) and a series of complex hypothetical modeling scenarios. Ultimately, the authors' conclusions stand at odds with real-world data showing decreases in ozone and PM2.5 concentrations during the period in which ethanol blending substantially increased in the United States. The findings also run counter to an existing body of research that shows ethanol reduces PM2.5 and emissions that contribute to the formation of urban ozone, including exhaust hydrocarbons and carbon monoxide (CO). Further, the paper is contradicted by the results of the Department of Energy's latest GREET model. Finally, the study omits important emissions sources from the petroleum and electric vehicle lifecycle, resulting in a "stacked deck" against ethanol.

THE STUDY'S CONCLUSIONS ARE UNDERMINED BY REAL-WORLD OZONE AND PM2.5 TRENDS

The paper's assertion that increased ethanol use would cause higher emissions of ozone and PM2.5 is contradicted by EPA data from actual air sensors. Data from 222 EPA sensing sites show that ozone and PM2.5 concentrations have trended downward during the period in which the use of ethanol-blended gasoline has dramatically increased.[2] Ozone concentrations have fallen 33% since 1980, while PM2.5 is down 34% just since 2000. In recent years, both ground-level ozone and PM2.5 emissions have dropped below their respective national standards, according to EPA. Specific "non-attainment" areas where reformulated gasoline (RFG) is required have shown similar reductions since ethanol was introduced as an oxygenate.

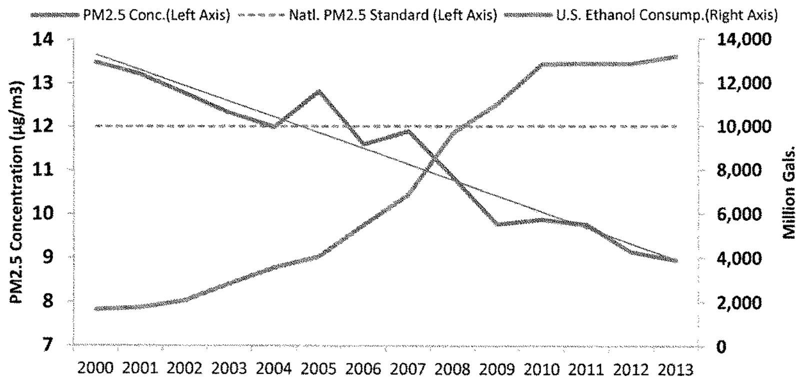
U.S. Ozone Concentration & Ethanol Consumption



[1] Tessum, C.W.; Hill, J.D.; and Marshall, J.D. "Life cycle air quality impacts of conventional and alternative light-duty transportation in the United States." Proceedings of the National Academies of Science. 10.1073/pnas.140685311.
[2] EPA Air Trends. http://www.epa.gov/airtrends/

 12.18.14

U.S. Fine Particulate (PM2.5) Concentration & Ethanol Consumption



Source: EPA Air Trends & EIA

THE STUDY'S FINDINGS ARE AT ODDS WITH EMISSIONS ESTIMATES FROM THE LATEST GREET MODEL

On a full lifecycle basis (i.e., including the contributions of upstream agriculture emissions), the study's results are contradictory to the results from the Department of Energy's latest GREET model.[3] This is particularly confusing because the authors claim to have used an earlier version of the GREET model for their analysis. It is unclear whether the authors adjusted key inputs in the GREET model, and on what scientific basis such adjustments might have been made.

The most recent GREET model shows **no increase** in PM2.5 emissions or other criteria pollutants when gasoline with 10% corn ethanol is compared to conventional gasoline without ethanol. Further, when E85 from corn ethanol is compared to conventional gasoline, GREET1_2014 shows that using **E85 decreases** urban emissions of volatile organic compounds (VOC), nitrous oxide (NOx), coarse particulates (PM10), fine particulates (PM2.5), and sulfur oxide (SOx).

The high levels of PM2.5 and ozone concentration attributed to corn ethanol in the Minnesota study appear to be mostly related to assumed upstream agricultural practices, such as fertilizer application. However, the paper and the supporting material do not clarify what assumptions were used for fertilizer production and application, or other agricultural activities. Further, the study omits NOx and SOx emissions for other fuels if those emissions occur "far from population centers." Yet, it appears *all* NOx and SOx emissions associated with agricultural production of biofuel feedstocks are included even though most feedstock production occurs in sparsely populated rural areas.

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[3] GREET1_2014. Available at https://greet.es.anl.gov/. See "Results" tab, "Gasoline Vehicle: Gasoline" and "Gasoline Vehicle: Low-Level EtOH Blend with Gasoline (E10, Corn, dry)."

OTHER RESEARCH SHOWS ETHANOL REDUCES THE POTENTIAL FOR OZONE AND PM2.5

Urban ozone formation occurs from rather complex atmospheric photochemistry, as volatile organic compounds (VOC) and carbon monoxide (CO) react in the presence of nitrogen oxides (NOx). Both the EPA and National Research Council have recognized that CO is a precursor to ozone formation. There is a substantial body of evidence proving that ethanol reduces both exhaust hydrocarbons and CO emissions, and thus can help reduce the formation of ground-level ozone. Indeed, ethanol's high oxygen content and ability to reduce exhaust hydrocarbons and CO emissions is the primary reason it is used as an important component of reformulated gasoline in cities with high smog levels.

Further, research has shown that increasing the oxygen content in gasoline reduces primary exhaust particulate matter (PM2.5) from the tailpipe. Because ethanol is 35% oxygen by weight, blending ethanol with gasoline increases the oxygen content of the fuel and thus reduces PM2.5 emissions.

THE STUDY USES QUESTIONABLE ASSUMPTIONS REGARDING OTHER FUELS

The Minnesota study's lifecycle emissions estimates for electric vehicles (EVs) *do not include emissions associates with battery production*, a glaring omission that creates an inconsistent framework for comparing various fuel/vehicle options. The authors admit that emissions associated with battery production account for **"about half"** of total EV lifecycle emissions—yet those emissions are excluded from the central scenario.

The study also *excludes NOx and SOx emissions associated with crude oil extraction*, a decision that grossly underrepresents the actual lifecycle emissions impacts of gasoline. These emissions were excluded because the authors assume they occur outside the geographical boundaries of their study area. The authors also assumed all crude oil in 2020 is extracted using conventional methods, which entirely ignores the emissions impacts of unconventional extraction techniques. According to the paper, "oil extraction from oil sands occurs outside of our geographic modeling domain," and thus they assume "all oil is extracted conventionally (0% oil sands oil)."

Omitting key emissions sources from the lifecycle assessment of EVs and crude oil inappropriately skews the paper's results for the overall emissions impacts of these fuels and vehicles.

Well-to-wheels energy use and greenhouse gas emissions of ethanol from corn, sugarcane and cellulosic biomass for US use

OPEN ACCESS
IOP PUBLISHING ENVIRONMENTAL RESEARCH LETTERS
Environ. Res. Lett. 7 (2012) 045905 (13pp) doi:10.1088/1748-9326/7/4/045905

Well-to-wheels energy use and greenhouse gas emissions of ethanol from corn, sugarcane and cellulosic biomass for US use

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Abstract
Globally, bioethanol is the largest volume biofuel used in the transportation sector, with corn-based ethanol production occurring mostly in the US and sugarcane-based ethanol production occurring mostly in Brazil. Advances in technology and the resulting improved productivity in corn and sugarcane farming and ethanol conversion, together with biofuel policies, have contributed to the significant expansion of ethanol production in the past 20 years. These improvements have increased the energy and greenhouse gas (GHG) benefits of using bioethanol as opposed to using petroleum gasoline. This article presents results from our most recently updated simulations of energy use and GHG emissions that result from using bioethanol made from several feedstocks. The results were generated with the GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) model. In particular, based on a consistent and systematic model platform, we estimate life-cycle energy consumption and GHG emissions from using ethanol produced from five feedstocks: corn, sugarcane, corn stover, switchgrass and miscanthus.

We quantitatively address the impacts of a few critical factors that affect life-cycle GHG emissions from bioethanol. Even when the highly debated land use change GHG emissions are included, changing from corn to sugarcane and then to cellulosic biomass helps to significantly increase the reductions in energy use and GHG emissions from using bioethanol. Relative to petroleum gasoline, ethanol from corn, sugarcane, corn stover, switchgrass and miscanthus can reduce life-cycle GHG emissions by 19–48%, 40–62%, 90–103%, 77–97% and 101–115%, respectively. Similar trends have been found with regard to fossil energy benefits for the five bioethanol pathways.

Keywords: corn ethanol, sugarcane ethanol, cellulosic ethanol, greenhouse gas emissions, energy balance, life-cycle analysis, biofuels

S Online supplementary data available from stacks.iop.org/ERL/7/045905/mmedia

1. Introduction

Globally, biofuels are being promoted for reducing greenhouse gas (GHG) emissions, enhancing the domestic energy

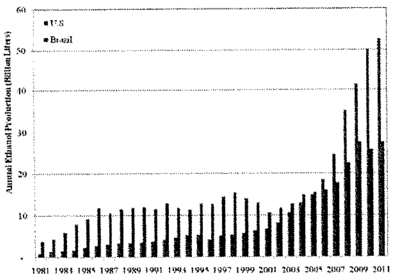

Figure 1. Annual ethanol production in the US and Brazil (based on data from the Renewable Fuels Association (RFA 2012) and Brazilian Sugarcane Association (UNICA 2012)).

security of individual countries and promoting rural economic development. In a carbon-constrained world, liquid transportation fuels from renewable carbon sources can play an important role in reducing GHG emissions from the transportation sector (IEA 2012). At present, the two major biofuels produced worldwide are (1) ethanol from fermentation of sugars primarily in corn starch and sugarcane and (2) biodiesel from transesterification of vegetable oils, with ethanol accounting for the majority of current biofuel production. Figure 1 shows the growth of annual ethanol production between 1981 and 2011 in the US and Brazil, the two dominant ethanol-producing countries.

The production of corn ethanol in the US has increased to more than 52 billion liters since the beginning of the US ethanol program in 1980. The increase after 2007, the year the Energy Independence and Security Act (EISA) came into effect, is remarkable. Growth in the production of Brazilian sugarcane ethanol began in the 1970s when the Brazilian government began to promote its production. The most recent growth in sugarcane ethanol production, since 2001, has mainly resulted from the popularity of ethanol flexible-fuel vehicles and from the advantageous price of ethanol over gasoline in Brazil.

Over the long term, the greatest potential for bioethanol production lies in the use of cellulosic feedstocks, which include crop residues (e.g., corn stover, wheat straw, rice straw and sugarcane straw), dedicated energy crops (e.g., switchgrass, miscanthus, mixed prairie grasses and short-rotation trees) and forest residues. The resource potential of these cellulosic feedstocks can support a huge amount of biofuel production. For example, in the US, nearly one billion tonnes of these resources are potentially available each year to produce more than 340 billion liters of ethanol per year (DOE 2011). This volume is significant, even when compared to the annual US consumption of gasoline, at 760 billion ethanol-equivalent liters (EIA 2012).

The GHG emission reduction potential of bioethanol, especially cellulosic ethanol, is recognized in policies that address reducing the transportation sector's GHG emissions (i.e., California's low-carbon fuel standard (LCFS; CARB 2009), the US renewable fuels standard (RFS; EPA 2010) and the European Union's renewable energy directive (RED; Neeft *et al* 2012)). Nonetheless, the life-cycle GHG emissions of bioethanol, especially those of corn-based ethanol, have been subject to debate (Farrell *et al* 2006, Fargione *et al* 2008, Searchinger *et al* 2008, Liska *et al* 2009, Wang *et al* 2011a, Khatiwada *et al* 2012). With regard to corn ethanol, some authors concluded that its life-cycle GHG emissions are greater than those from gasoline (Searchinger *et al* 2008, Hill *et al* 2009). Others concluded that corn ethanol offers reductions in life-cycle GHG emissions when compared with gasoline (Liska *et al* 2009, Wang *et al* 2011a). On the other hand, most analyses of cellulosic ethanol reported significant reductions in life-cycle GHG emissions when compared with those from baseline gasoline. Reductions of 63% to 118% have been reported (Borrion *et al* 2012, MacLean and Spatari 2009, Monti *et al* 2012, Mu *et al* 2010, Scown *et al* 2012, Wang *et al* 2011a, Whitaker *et al* 2010). Most of these studies included a credit for the displacement of grid electricity with electricity co-produced at cellulosic ethanol plants from the combustion of lignin. Some, however, excluded co-products (e.g., MacLean and Spatari 2009). Uniquely, Scown *et al* (2012) considered land use change (LUC) GHG emissions (for miscanthus ethanol) and estimated total net GHG sequestration of up to 26 g of CO_2 equivalent (CO_2e)/MJ of ethanol. In the case of sugarcane ethanol, Seabra *et al* (2011) and Macedo *et al* (2008) reported life-cycle GHG emissions that were between 77% and 82% less than those of baseline gasoline. Wang *et al* (2008) estimated this reduction to be 78%.

A detailed assessment of the completed studies requires that they be harmonized with regard to the system boundary, co-product allocation methodology, and other choices and assumptions that were made. Other researchers (e.g., Chum *et al* 2011) have undertaken this task to some extent. Here we instead use a consistent modeling platform to examine the GHG impacts from using corn ethanol, sugarcane ethanol and cellulosic ethanol. The GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) model that we developed at Argonne National Laboratory has been used by us and many other researchers to examine GHG emissions from vehicle technologies and transportation fuels on a consistent basis (Argonne National Laboratory 2012). The GREET model covers bioethanol production pathways extensively; we have updated key parameters in these pathways based on recent research. This article presents key GREET parametric assumptions and life-cycle energy and GHG results for bioethanol pathways contained in the GREET version released in July 2012. Moreover, we quantitatively address the impacts of critical factors that affect GHG emissions from bioethanol.

2. Scope, methodology, and key assumptions

We include bioethanol production from five feedstocks: corn grown in the US, sugarcane grown in Brazil, and corn stover, switchgrass and miscanthus, all grown in the US. Even though the wide spread drought in the US midwest in the summer of 2012 may dampen corn ethanol production in 2012, corn

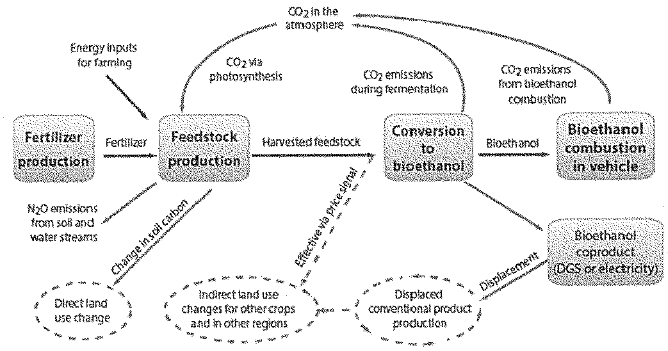

Figure 2. System boundary of well-to-wheels analysis of bioethanol pathways.

ethanol production will continue to grow, possibly exceeding the goal of 57 billion liters per year in the 2007 EISA. Likewise, Brazil's sugarcane ethanol production will continue to grow. In the US midwest corn belt, up to 363 million tonnes of corn stover can be sustainably harvested in a year (DOE 2011). Large-scale field trials have been in place to collect and transport corn stover (Edgerton *et al* 2010). Switchgrass is a native North American grass. Field trials of growing switchgrass as an energy crop have been in place since the 1980s. Miscanthus, on the other hand, has a high potential yield per acre. In the past several years, significant efforts have been made in the US to develop better varieties of miscanthus with higher yields (Somerville *et al* 2010).

We conducted the well-to-wheels (WTW, or, more precisely for bioethanol, field-to-wheels) analyses of the five bioethanol pathways with the GREET model (Argonne National Laboratory 2012, Han *et al* 2011, Dunn *et al* 2011, Wang *et al* 2012). In particular, we used the most recent GREET version (GREET1_2012) for this analysis to conduct simulations for the year 2015. Figure 2 presents the system boundary for the five bioethanol pathways in our analysis. Parametric details of the five pathways are presented below. For comparison, we included petroleum gasoline in our analysis.

The GREET model is designed with a stochastic modeling tool to address the uncertainties of key parameters and their effects on WTW results. For this article, we used that feature to conduct simulations with probability distribution functions for key parameters in the WTW pathways. In addition, we conducted parametric sensitivity analyses to test the influence of key parameters on GHG emissions for each of the five pathways.

2.1. Corn-to-ethanol in the US

For the corn-to-ethanol pathway, corn farming and ethanol production are the two major direct GHG sources (Wang *et al* 2011a). From farming, N_2O emissions from the nitrification and denitrification of nitrogen fertilizer in cornfields, fertilizer production and fossil fuel use for farming are significant GHG emission sources. GHG emissions during ethanol production result from the use of fossil fuels, primarily natural gas (NG), in corn ethanol plants. GREET takes into account GHG emissions from NG production and distribution (such as methane leakage during these activities (see Burnham *et al* 2012)) as well as those from NG combustion. The treatment of distillers' grains and solubles (DGS), a valuable co-product from corn ethanol plants, in the life-cycle analysis (LCA) of corn ethanol is important because it can affect results regarding corn ethanol's GHG emissions (Wang *et al* 2011b). Table 1 presents key parametric assumptions in GREET for corn-based ethanol. In this and subsequent tables, P10 and P90 represent the 10th and 90th percentiles, respectively, of these parameters.

2.2. Production of ethanol from sugarcane in Brazil for use in the US

Brazilian sugarcane mills produce both ethanol and sugar, with the split between them readily adjusted to respond to market prices. Bagasse, the residue after sugarcane juice is squeezed from sugarcane, is combusted in sugar mills to produce steam (for internal use) and electricity (for internal use and for export to the electric grid). Sugarcane farming is associated with significant GHG emissions from both upstream operations such as fertilizer production and from the field itself. For example, the nitrogen (N) in sugarcane residues (i.e., straw) on the field as well as the N in fertilizer emit N_2O. The sugar mill by-products vinasse and filter cake applied as soil amendments also emit N_2O as a portion of the N in them degrades (Braga do Carmo *et al* 2012). Open field burning, primarily with manual harvesting of sugarcane (which is being phased out), and transportation logistics (truck transportation of sugarcane from fields to mills and of ethanol from mills to Brazilian ports; ocean tanker transportation of ethanol from southern Brazilian ports to US ports; and US ethanol transportation) are also key GHG emission sources in the sugarcane ethanol life cycle. Table 2

Table 1. Parametric assumptions about the production of ethanol from corn in the US.

Parameter: unit	Mean	P10	P90	Distribution function type
Corn farming: per tonne of corn (except as noted)				
Direct energy use for corn farming: MJ	379	311	476	Weibull[a]
N fertilizer application: kg	15.5	11.9	19.3	Normal[a]
P fertilizer application: kg	5.54	2.86	8.61	Lognormal[a]
K fertilizer application: kg	6.44	1.56	12.5	Weibull[a]
Limestone application: kg	43.0	38.7	47.3	Normal[a]
N_2O conversion rate of N fertilizer: %	1.525	0.413	2.956	Weibull[b]
NG use per tonne of ammonia produced: GJ	30.7	28.1	33.1	Triangular[c]
Corn ethanol production				
Ethanol yield: l/tonne of corn	425	412	439	Triangular[a]
Ethanol plant energy use: MJ/l of ethanol	7.49	6.10	8.87	Normal[a]
DGS yield: kg (dry matter basis)/l of ethanol	0.676	0.609	0.743	Triangular[a]
Enzyme use: kg/tonne of corn	1.04	0.936	1.15	Normal[d]
Yeast use: kg/tonne of corn	0.358	0.323	0.397	Normal[d]

[a] The type and shape of distribution functions were developed in Brinkman *et al* (2005). The means of the distributions were scaled later to the values in Wang *et al* (2007, 2011a).
[b] Based on our new assessment of the literature, see supporting information (available at stacks.iop.org/ERL/7/045905/mmedia) for details.
[c] From Brinkman *et al* (2005).
[d] Selected among 11 distribution function types, with maximization of the goodness-of-fit method to the data compiled in Dunn *et al* (2012a).

Table 2. Parametric assumptions about the production of sugarcane ethanol in Brazil and its use in the US (per tonne of sugarcane, except as noted).

Parameter: unit	Mean	P10	P90	Distribution function type
Sugarcane farming				
Farming energy use for sugarcane: MJ	100	90.2	110	Normal[a]
N fertilizer use: g	800	720	880	Normal[a]
P fertilizer use: g	300	270	330	Normal[a]
K fertilizer use: g	1000	900	1100	Normal[a]
Limestone use: g	5200	4680	5720	Normal[a]
Yield of sugarcane straw: kg	140	126	154	Normal[a]
Filter cake application rate: kg (dry matter basis)	2.87	2.58	3.16	Normal[a]
Vinasse application rate: l	570	513	627	Normal[a]
Share of mechanical harvest: % of total harvest	80	NA[b]	NA[b]	Not selected
N_2O conversion rate of N fertilizer: %	1.22	1.05	1.39	Uniform[c]
Sugarcane ethanol production				
Ethanol yield: l	81.0	73.1	89.0	Normal[a]
Ethanol plant energy use: fossil kJ/l of ethanol	83.6	75.3	92.0	Normal[a]
Electricity yield: kWh	75	57.8	100	Exponential[a]
Sugarcane ethanol transportation				
Ethanol transportation inside of Brazil: km	690	NA[b]	NA[b]	Not selected
Ethanol transportation from Brazil to the US: km	11 930	NA[b]	NA[b]	Not selected

[a] By maximization of goodness-of-fit to the data in Macedo *et al* (2004, 2008) and Seabra *et al* (2011).
[b] NA = not available.
[c] Data on N_2O emissions from sugarcane fields is very limited, so we assumed uniform distribution. See supporting information (available at stacks.iop.org/ERL/7/045905/mmedia) for details.

lists key parametric assumptions for the sugarcane-to-ethanol pathway. We did not have data on enzyme and yeast use for sugarcane ethanol production, so their impacts are not considered in this analysis. Given that enzymes and yeast have a minor impact on corn ethanol WTW results (Dunn *et al* 2012a), we expect that their effect on sugarcane WTW results are small as well.

2.3. Corn stover-, switchgrass- and miscanthus-to-ethanol

The yield of corn stover in cornfields could match corn grain yield on a dry matter basis. For example, for a corn grain yield of 10 tonnes (with 15% moisture content) per hectare, the corn stover yield could be 8.5 tonnes (bone dry) per hectare. Studies concluded that one-third to one-half of corn stover in cornfields can be sustainably removed without causing

Table 3. Cellulosic ethanol production parametric assumptions (per dry tonne of cellulosic biomass, except as noted).

Parameter: unit	Mean	P10	P90	Distribution function type
Corn stover collection				
Energy use for collection: MJ	219	197	241	Normal[a]
Supplemental N fertilizer: g	8488	6499	10 476	Normal[a]
Supplemental P fertilizer: g	2205	1102	3307	Normal[a]
Supplemental K fertilizer: g	13 228	7491	18 964	Normal[a]
Switchgrass farming				
Farming energy use: MJ	144	89.1	199	Normal[b]
N fertilizer use: g	7716	4783	10 649	Normal[b]
P fertilizer use: g	110	77	143	Normal[b]
K fertilizer use: g	220	154	287	Normal[b]
N_2O conversion rate of N fertilizer: %	1.525	0.413	2.956	Weibull[c]
Miscanthus farming				
Farming energy use: MJ	153	138	168	Normal[d]
N fertilizer use: g	3877	2921	4832	Normal[d]
P fertilizer use: g	1354	726	1981	Normal[d]
K fertilizer use: g	5520	3832	7209	Normal[d]
N_2O conversion rate of N fertilizer: %	1.525	0.413	2.956	Weibull[c]
Cellulosic ethanol production[e]				
Ethanol yield: l	375	328	423	Normal[f]
Electricity yield: kWh	226	162	290	Triangular[f]
Enzyme use: grams/kg of substrate (dry matter basis)	15.5	9.6	23	Triangular[g]
Yeast use: grams/kg of substrate (dry matter basis)	2.49	2.24	27.4	Normal[g]

[a] By maximization of goodness-of-fit to the data compiled in Han et al (2011).
[b] By maximization of goodness-of-fit to the data compiled in Dunn et al (2011).
[c] Based on our new assessment of the literature, see supporting information (available at stacks.iop.org/ERL/7/045905/mmedia) for details.
[d] By maximization of goodness-of-fit to the data compiled in Wang et al (2012).
[e] Although we anticipated differences in plant yields and inputs among the three cellulosic feedstocks, we did not find enough data to quantify the differences for this study.
[f] The type and shape of distribution functions were developed in Brinkman et al (2005). The means of the distributions were scaled later to the values in Wang et al (2011a).
[g] By maximization of goodness-of-fit to the data compiled in Dunn et al (2012a).

erosion or deteriorating soil quality (Sheehan et al 2008, DOE 2011). When stover is removed, N, P and K nutrients are removed, too. We assumed in GREET simulations that the amount of nutrients lost with stover removal would be supplemented with synthetic fertilizers. We developed our replacement rates based on data for nutrients contained in harvested corn stover found in the literature (Han et al 2011).

Switchgrass can have an annual average yield of 11–13 tonnes ha^{-1}, with the potential of more than 29 tonnes ha^{-1} (Sokhansanj et al 2009). To maintain a reasonable yield, fertilizer is required for switchgrass growth. In arid climates, irrigation may be also required. In our analysis, we assumed that switchgrass would be grown in the midwest, south and southeast US without irrigation. Miscanthus can have yields above 29 tonnes ha^{-1} (with up to 40 tonnes) (Somerville et al 2010). Similar to switchgrass, fertilizer application may be required in order to maintain good yields.

In cellulosic ethanol plants, cellulosic feedstocks go through pretreatment with enzymes that break cellulose and hemicellulose into simple sugars for fermentation. The lignin portion of cellulosic feedstocks can be used in a combined heat and power (CHP) generator in the plant. The CHP generator can provide process heat and power in addition to surplus electricity for export to the grid. Ethanol and electricity yields in cellulosic ethanol plants are affected by the composition of cellulosic feedstocks (although we did not find enough data to identify the differences in ethanol and electricity yield for our study). Lignin can also be used to produce bio-based products instead of combustion. In our analysis, we assume combustion of lignin for steam and power generation. Table 3 presents key assumptions for the three cellulosic ethanol pathways.

2.4. Land use change from bioethanol production

Since 2009, we have been addressing potential LUC impacts of biofuel production from corn, corn stover, switchgrass and miscanthus with Purdue University and the University of Illinois (Taheripour et al 2011, Kwon et al 2012, Mueller et al 2012, Dunn et al 2012b). We developed estimates of LUC GHG emissions with a GREET module called the Carbon

Calculator for Land Use Change from Biofuels Production (CCLUB) (Mueller *et al* 2012). In CCLUB, we combine LUC data generated by Purdue University from using its Global Trade Analysis Project (GTAP) model (Taheripour *et al* 2011) and domestic soil organic carbon (SOC) results from modeling with CENTURY, a soil organic matter model (Kwon *et al* 2012) that calculates net carbon emissions from soil. Above ground carbon data in CCLUB for forests comes from the carbon online estimator (COLE) developed by the USDA and the National Council for Air and Stream Improvement (Van Deusen and Heath 2010). International carbon emission factors for various land types are from the Woods Hole Research Center (reproduced in Tyner *et al* (2010)). We provide a full analysis of CCLUB results for these feedstocks elsewhere (Dunn *et al* 2012b) and summarize them briefly here.

When land is converted to the production of biofuel feedstock, direct impacts are changes in below ground and above ground carbon content, although the latter is of concern mostly for forests. These LUC-induced changes cause SOC content to either decrease or increase, depending on the identity of the crop. For example, if land is converted from cropland-pasture to corn, SOC will decrease, and carbon will be released to the atmosphere. However, conversion of this same type of land to miscanthus or switchgrass production likely sequesters carbon (Dunn *et al* 2012b). This sequestration will continue for a certain length of time until an SOC equilibrium is reached. Equilibrium seems to occur after about 100 years in the case of switchgrass (Andress 2002) and 50 years in the case of miscanthus (Hill *et al* 2009, Scown *et al* 2012). This time-dependence of GHG emissions associated with LUC presents a challenge in biofuel LCA. The most appropriate time horizon for SOC changes and the treatment of future emissions as compared to near-term emissions is an open research question (Kløverpris and Mueller 2012, O'Hare *et al* 2009). On one hand, a near-term approach in which the time frame is two or three decades could be used. The advantages of this approach include assigning more importance to near-term events that are more certain. Some LCA standards, such as PAS 2050 (BSI 2011) advocate a 100 year time horizon for the LCA of any product. If such an extended time horizon is used, however, future emissions should be discounted, although the methodology for this discounting is unresolved. In addition, the uncertainty associated with land use for over a century is very large. Given these factors, we assume a 30 year period for both soil carbon modeling and for amortizing total LUC GHG emissions over biofuel production volume during this period. This approach, which aligns with the EPA's LCA methodology for the RFS (EPA 2010), may result in a slightly conservative estimate for the soil carbon sequestration that might be associated with switchgrass and miscanthus production, because lands producing these crops will continue to sequester carbon after the 30 year time horizon of this analysis. On the other hand, this selection gives a higher GHG sequestration rate per unit of biofuel since the total biofuel volume for amortization is smaller.

Our modeling with CCLUB indicates that of the feedstocks examined, corn ethanol had the largest LUC GHG emissions (9.1 g CO_2e MJ^{-1} of ethanol), whereas LUC emissions associated with miscanthus ethanol production caused substantial carbon sequestration (-12 g CO_2e MJ^{-1}). Switchgrass ethanol production results in a small amount of LUC emissions: 1.3 g CO_2e MJ^{-1}. LUC emissions associated with corn stover ethanol production result in a GHG sequestration of -1.2 g CO_2e MJ^{-1}. It is important to note that these results were generated by using one configuration of modeling assumptions in CCLUB. Elsewhere we describe how these results vary with alternative CCLUB configurations (Dunn *et al* 2012b).

We have not conducted LUC GHG modeling for sugarcane ethanol. The EPA reported LUC GHG emissions for sugarcane ethanol of 5 g CO_2e MJ^{-1} (EPA 2010). This value does not include indirect effects of LUC beyond SOC changes, such as changes in emissions from rice fields and livestock production. The United Kingdom Department of Transport (E4Tech 2010) estimated indirect land use change (iLUC) associated with sugarcane ethanol as ranging between 18 and 27 g CO_2e MJ^{-1}. Another recent report estimates sugarcane LUC GHG emissions as 13 g CO_2e MJ^{-1} (ATLASS Consortium 2011). CARB estimated that these emissions were 46 g CO_2e MJ^{-1} (Khatiwada *et al* 2012) but is revisiting that value. The EU is proposing LUC GHG emissions of 13 g CO_2e MJ^{-1} (EC 2012). Without considering the CARB value, we decided to use LUC GHG emissions of 16 g CO_2e MJ^{-1} for sugarcane ethanol.

2.5. *Petroleum gasoline*

We made petroleum gasoline the baseline fuel to which the five ethanol types are compared. The emissions and energy efficiency associated with gasoline production are affected by the crude oil quality, petroleum refinery configuration, and gasoline quality. Of the crude types fed to US refineries, the Energy Information Administration (EIA 2012) predicts that in 2015 (the year modeled for this study), 13.4% of US crude will be Canadian oil sands. Based on EIA reports, we estimated 5.1% of US crude would be Venezuelan heavy and sour crude, and the remaining 81.5% would be conventional crude. The former two are very energy-intensive and emissions-intensive to recover and refine. US petroleum refineries are configured to produce gasoline and diesel with a two-to-one ratio by volume, while European refineries are with a one-to-two ratio. A gasoline-specific refining energy efficiency is needed for gasoline WTW analysis, and it is often calculated with several allocation methods (Wang *et al* 2004, Bredeson *et al* 2010, Palou-Rivera *et al* 2011). Also, methane flaring and venting could be a significant GHG emission source for petroleum gasoline. Table 4 lists the key parametric assumptions for petroleum gasoline.

2.6. *Treatment of co-products in bioethanol and gasoline LCA*

Table 5 lists co-products, the products they displace and the co-product allocation methodologies for the six pathways included in this article. The displacement method is

Table 4. Petroleum gasoline parametric assumptions (per GJ of crude oil, except as noted).

Parameter: unit	Mean	P10	P90	Distribution function type
Conventional crude				
Conventional crude recovery efficiency: %	98.0	97.4	98.6	Triangular[a]
Heavy and sour crude recovery efficiency: %	87.9	87.3	88.5	Triangular[b]
CH_4 venting: g	7.87	6.26	9.48	Normal[c]
CO_2 from associated gas flaring/venting: g	1355	1084	1627	Normal[c]
Oil sands—surface mining (48% in 2015)				
Bitumen recovery efficiency: %	95.0	94.4	95.6	Triangular[d]
CH_4 venting: g	12.8	7.42	198	Normal[e]
CO_2 from associated gas flaring: g	187	83.9	289	Normal[e]
Hydrogen use for upgrade: MJ	84.2	67.4	101	Normal[d]
Oil sands—*in situ* production (52% in 2015)				
Bitumen recovery efficiency: %	85.0	83.6	86.5	Triangular[d]
Hydrogen use for upgrade: MJ	32.3	25.9	38.8	Normal[d]
Crude refining				
Gasoline refining efficiency: %	90.6	88.9	92.3	Normal[f]

[a] From Brinkman *et al* (2005).
[b] Based on Rosenfeld *et al* (2009).
[c] By maximization of goodness-of-fit to the data compiled in Palou-Rivera *et al* (2011).
[d] From Larsen *et al* (2005).
[e] Based on Bergerson *et al* (2012).
[f] The type and shape of distribution functions were developed in Brinkman *et al* (2005). The means of the distributions were scaled later to the values in Palou-Rivera *et al* (2011).

Table 5. Co-products of bioethanol and gasoline pathways and co-product allocation methodologies.

Pathway	Co-product	Displaced products	LCA method used in this study	Alternative LCA methods available in GREET	References
Corn ethanol	DGS[a]	Soybean, corn, and other animal feeds	Displacement	Allocation based on market revenue, mass or energy	Wang *et al* (2011b); Arora *et al* (2011)
Sugarcane ethanol	Electricity from bagasse	Conventional electricity	Allocation based on energy[b]	Displacement[c]	Wang *et al* (2008)
Cellulosic ethanol (corn stover, switchgrass and miscanthus)	Electricity from lignin	Conventional electricity	Displacement[d]	Allocation based on energy	Wang *et al* (2011b)
Petroleum gasoline	Other petroleum products	Other petroleum products	Allocation based on energy	Allocation based on mass, market revenue and process energy use	Wang *et al* (2004); Bredeson *et al* (2010); Palou-Rivera *et al* (2011)

[a] Dry mill corn ethanol plants produce dry and wet DGS with shares of 65% and 35% (on a dry matter basis), respectively. We include these shares in our analysis.
[b] Electricity output accounts for 14% of the total energy output of sugarcane ethanol plants. With such a significant share of electricity, we decided to use the energy allocation method for ethanol and electricity rather than the displacement method.
[c] With the displacement method, if we assume that the co-produced electricity displaces the Brazilian average electricity mix (with 83% from hydro power), the sugarcane ethanol results are similar to those when the energy allocation method is used. If the co-produced electricity displaces NG combined cycle power, WTW sugarcane ethanol GHG emissions are reduced by 21 g CO_2e MJ^{-1}.
[d] We assumed that co-produced electricity replaces the US average electricity mix in 2015 (with 44% from coal and 21% from NG (EIA 2012) and a GHG emission rate of 635 g CO_2e kWh^{-1}). If co-produced electricity displaces the US midwest generation mix (with 74% from coal and 4% from NG and a GHG emission rate of 844 g CO_2e kWh^{-1}), cellulosic ethanol WTW GHG emissions are reduced by 5.7 g CO_2e MJ^{-1}. If co-produced electricity displaces NG combined cycle power (with a GHG emission rate of 539 g CO_2e kWh^{-1}), cellulosic ethanol GHG emissions are increased by 2.5 g CO_2e MJ^{-1} from the base case.

recommended by the International Standard Organization and was used by EPA and CARB. However, the energy allocation method was used by the European Commission. Wang *et al* (2011b) argued that while there is no universally accepted method to treat co-products in biofuel LCA, the transparency of methodology and the impacts of methodology choices should be presented in individual studies to better inform readers.

Table 6. Energy balance and energy ratio of bioethanol.

	Corn	Sugarcane	Corn stover	Switchgrass	Miscanthus
Energy balance (MJ l^{-1})[a]	10.1	16.4	20.4	21.0	21.4
Energy ratio	1.61	4.32	4.77	5.44	6.01

[a] A liter of ethanol contains 21.3 MJ of energy (lower heating value).

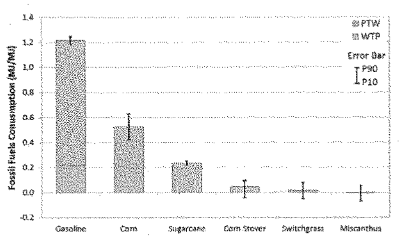

Figure 3. Well-to-wheels results for fossil energy use of gasoline and bioethanol.

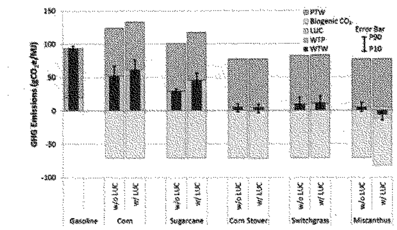

Figure 4. Well-to-wheels results for greenhouse gas emissions in CO_2e for six pathways.

3. Results

We present WTW results for energy use and GHG emissions for the five bioethanol pathways and baseline gasoline (a blending stock without ethanol or other oxygenates). Energy use results for this study include total energy use, fossil energy use, petroleum use, natural gas use and coal use. Because of space limitations, only fossil energy use results (including petroleum, coal and natural gas) are presented here. GHG emissions here are CO_2-equivalent emissions of CO_2, CH_4 and N_2O, with 100 year global warming potentials of 1, 25 and 298, respectively, per the recommendation of the International Panel on Climate Change (Eggleston *et al* 2006).

Figure 3 presents WTW results for fossil energy use per MJ of fuel produced and used. The chart presents the well-to-pump (WTP) stage (more precisely, in the bioethanol cases, field-to-pump stage) and pump-to-wheels (PTW) stage. The WTP and PTW bars together represent WTW results. The error bars represent values with P10 (the lower end of the line) and P90 (the higher end of the line) for WTW results.

Selection of the MJ functional unit here means that energy efficiency differences between gasoline and ethanol vehicles are not taken into account. On an energy basis (or gasoline-equivalent basis), vehicle efficiency differences for low-level and mid-level blends of ethanol in gasoline are usually small. If engines are designed to take advantage of the high octane number of ethanol, however, high-level ethanol blends could improve vehicle efficiency.

For petroleum gasoline, the largest amount of fossil energy is used in the PTW stage because gasoline energy is indeed fossil-based. In contrast, the five ethanol pathways do not consume fossil energy in the PTW stage. With regard to WTP fossil energy use, corn ethanol has the largest amount due to the intensive use of fertilizer in farming and use of energy (primarily NG) in corn ethanol plants. Other ethanol pathways have minimum fossil energy use. In fact, the P10 fossil energy values for the three cellulosic ethanol types are negative for two reasons. First, fossil energy use during farming and ethanol production for these pathways is minimal. Second, the electricity generated in cellulosic ethanol plants can displace conventional electricity generation, which, in the US, is primarily fossil energy based. Relative to gasoline, ethanol from corn, sugarcane, corn stover, switchgrass and miscanthus, on average, can reduce WTW fossil energy use by 57%, 81%, 96%, 99% and 100%, respectively.

An energy balance or energy ratio is often presented for bioethanol to measure its energy intensity. Table 6 presents energy balances and ratios of the five bioethanol pathways. The energy balance is calculated as the difference between the energy content of ethanol and the fossil energy used to produce it. Energy ratios are calculated as the ratio between the two. All five ethanol types have positive energy balance values and energy ratios greater than one.

Figure 4 shows WTW GHG emissions of the six pathways. GHG emissions are separated into WTP, PTW, biogenic CO_2 (i.e., carbon in bioethanol) and LUC GHG emissions. Combustion emissions are the most significant GHG emission source for all fuel pathways. However, in the five bioethanol cases, biogenic CO_2 in ethanol offsets ethanol combustion GHG emissions almost entirely. LUC GHG emissions, as discussed in an earlier section, are from the CCLUB simulations for the four bioethanol pathways (corn, corn stover, switchgrass and miscanthus). LUC emissions of Brazilian sugarcane ethanol are based on our review of available literature. It is not possible to maintain a consistent analytical approach among these unharmonized literature studies of sugarcane ethanol and between them and CCLUB modeling results. Because of the ongoing debate regarding the values and associated uncertainties of LUC GHG emissions, we provide two separate sets of results for ethanol: one with LUC emissions included, and the other with LUC emissions excluded.

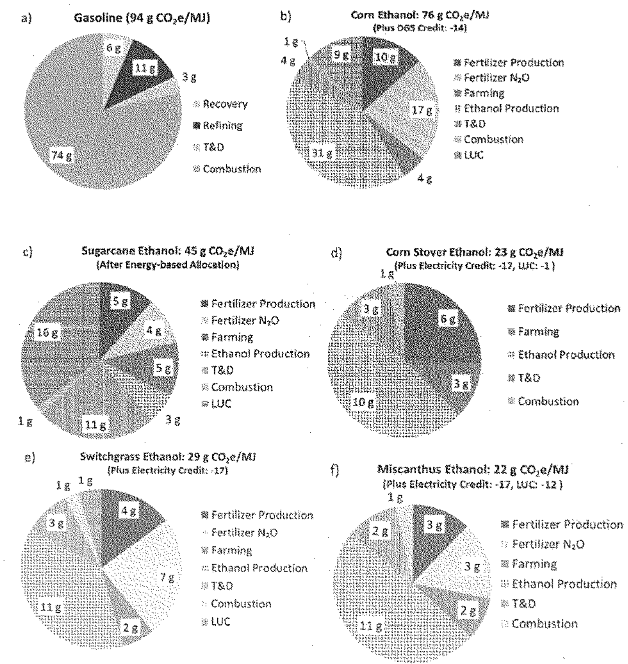

Figure 5. Shares of GHG emissions by activities for (a) gasoline, (b) corn ethanol, (c) sugarcane ethanol, (d) corn stover ethanol, (e) switchgrass ethanol and (f) miscanthus ethanol (results were generated by using the co-product allocation methodologies listed in table 6).

Table 7. WTW GHG emission reductions for five ethanol pathways (relative to WTW GHG emissions for petroleum gasoline). (Note: Values in the table are GHG reductions for P10–P90 (P50), all relative to the P50 value of gasoline GHG emissions.)

WTW GHG emission reductions	Corn	Sugarcane	Corn stover	Switchgrass	Miscanthus
Including LUC emissions	19–48% (34%)	40–62% (51%)	90–103% (96%)	77–97% (88%)	101–115% (108%)
Excluding LUC emissions	29–57% (44%)	66–71% (68%)	89–102% (94%)	79–98% (89%)	88–102% (95%)

Of the five bioethanol pathways, corn and sugarcane ethanol have significant WTP GHG emissions and LUC GHG emissions. Miscanthus ethanol has significant negative LUC GHG emissions due to the increased SOC content from miscanthus growth. Sugarcane ethanol shows great variation in LUC emissions, mainly due to differences in assumptions and modeling methodologies among the reviewed studies. Table 7 shows numerical GHG emission reductions of the five ethanol pathways relative to those of petroleum gasoline.

The pie charts in figure 5 show contributions of key life-cycle stages to WTW GHG emissions for the six pathways. With regard to gasoline WTW GHG emissions, 79% are from combustion of gasoline and 12% are from petroleum refining. Crude recovery and transportation activities contribute the remaining 9%. For corn ethanol, ethanol plants account for 41% of total GHG emissions; fertilizer production and N_2O emissions from cornfields account for 36%; LUC accounts for 12%; and corn farming energy use and transportation activities account for small shares. For sugarcane ethanol, LUC accounts for 36% of total GHG emissions (however, LUC GHG emissions data here are from a literature review rather than our own modeling). Transportation of sugarcane and ethanol contributes to 24% of total GHG emissions. Together, fertilizer production and N_2O

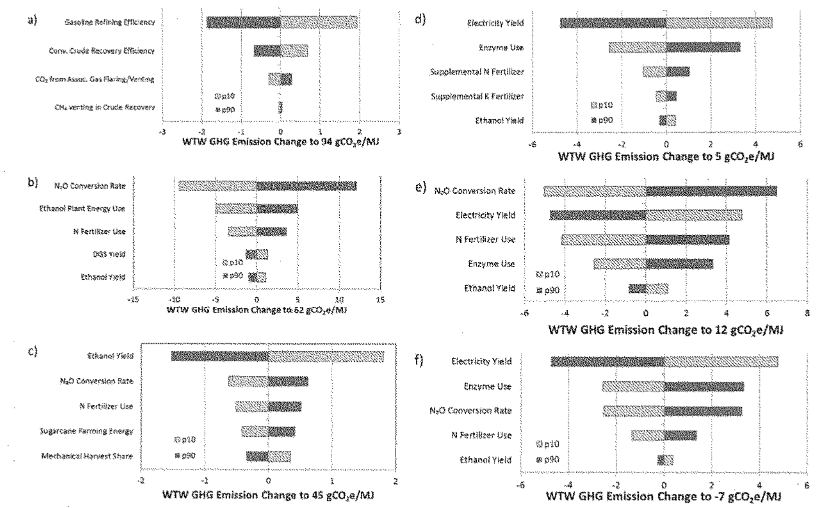

Figure 6. Sensitivity analysis results for (a) conventional crude to gasoline, (b) corn ethanol, (c) sugarcane ethanol, (d) corn stover ethanol, (e) switchgrass ethanol and (f) miscanthus ethanol.

emissions from sugarcane fields account for 20% of these emissions. Finally, the contribution of sugarcane farming to WTW GHG emissions is 11%.

Although for corn ethanol, the greatest contributor to life-cycle GHG emissions is the production of ethanol itself, this step is less significant in the life cycle of sugarcane ethanol because sugar mills use bagasse to generate steam and electricity. Another contrast between these two sugar-derived biofuels is the transportation and distribution (T&D) stage. Corn ethanol, produced domestically in the US, is substantially less affected by T&D than is sugarcane ethanol, which is trucked for long distances to Brazilian ports and transported across the ocean via ocean tankers to reach US consumers.

For the three cellulosic ethanol pathways, ethanol production is the largest GHG emission source. Fertilizer production and associated N_2O emissions (only in the case of switchgrass and miscanthus) are the next largest GHG emission source. Farming and transportation activities also have significant emission shares. One notable aspect of figure 5(e) is the positive contribution of LUC GHG emissions in the switchgrass ethanol life cycle when compared to the other cellulosic feedstocks, which may sequester GHG as a result of LUC. These results are explained elsewhere (Dunn *et al* 2012b).

To show the importance of key parameters affecting WTW GHG emissions results for a given fuel pathway, we conducted a sensitivity analysis of GHG emissions with GREET for all six pathways with P10 and P90 values as the minimum and maximum value for each parameter. We present the five most influential parameters for each pathway in the so-called tornado charts in figure 6.

For petroleum gasoline, the gasoline refining efficiency and recovery efficiency of the petroleum feedstock are the most sensitive parameters. For corn ethanol, the N_2O conversion rate in cornfields is the most sensitive factor, followed by the ethanol plant energy consumption. Enzyme and yeast used in the corn ethanol production process are not among the five most influential parameters in the corn ethanol life cycle. For sugarcane ethanol, the most significant parameters, in order of importance, are ethanol yield per unit of sugarcane, the N_2O conversion rate in sugarcane fields, nitrogen fertilizer usage intensity, sugarcane farming energy use and the mechanical harvest share. Sugarcane farming is evolving as mechanical harvesting becomes more widespread and mill by-products are applied as soil amendments. We thus expect to see shifts in the identity and magnitude of influence of the key parameters in the sugarcane-to-ethanol pathway in the future.

The three cellulosic ethanol pathways have similar results. The electricity credit is the most significant parameter (except for switchgrass ethanol, for which the N_2O conversion rate is the most significant). Enzyme use is a more significant factor in cellulosic ethanol pathways than in the corn ethanol pathway because the greater recalcitrance of the feedstock currently requires higher enzyme dosages in the pretreatment stage (Dunn *et al* 2012a). The impact of fertilizer-related parameters on WTW GHG emissions results depends, as one would expect, on the fertilizer intensity of feedstock farming (see table 3).

The strong dependence of results on the N_2O conversion rate is notable for four out of the five ethanol pathways (the exception is corn stover, where the same amount of nitrogen in either in the stover or supplemental fertilizer results in same amount of N_2O emissions, with or without stover collection). Great uncertainty exists regarding N_2O conversion rates in agricultural fields because many factors (including soil type, climate, type of fertilizer and fertilizer application method) affect the conversion. We conducted an extensive literature review for this study to revise N_2O conversion rates in GREET (see supporting information available at stacks.iop.org/ERL/7/045905/mmedia). The original GREET conversion rate was based primarily on IPCC tier 1 rates. With newly available data, we adjusted our direct conversion rates in cornfields upward (see supporting information available at stacks.iop.org/ERL/7/045905/mmedia for details). In particular, we developed a Weibull distribution function for direct and indirect N_2O emissions together with a mean value of 1.525%, a P10 value of 0.413% and P90 value of 2.956%. In comparison, our original distribution function for total N_2O conversion rates was a triangular distribution, with a most likely value of 1.325%, a minimum value of 0.4% and a maximum value of 2.95%.

4. Discussion

Our results for cellulosic ethanol are in line with two recent studies that reported life-cycle GHG emissions of switchgrass and miscanthus ethanol. Monti *et al* (2012) reported that switchgrass ethanol life-cycle GHG emissions are 63% to 118% lower than gasoline, based on a literature review. Scown *et al* (2012) conducted an LCA of miscanthus ethanol and reported its life-cycle GHG emissions as being -26 g CO_2e MJ^{-1} of ethanol when impacts of both co-produced electricity and soil carbon sequestration were included. We estimate slightly lower reductions for sugarcane ethanol than did Seabra *et al* (2011) and Macedo *et al* (2008). Our results for corn ethanol, however, contrast with those of Searchinger *et al* (2008) and Hill *et al* (2009), who predicted that corn ethanol would have a greater life-cycle GHG impact than gasoline, mainly due to LUC GHG emissions among those studies and ours.

Advances and complexities in ethanol production technologies, especially for cellulosic ethanol, could alter bioethanol LCA results in the future. For example, although we examined corn and cellulosic ethanol plants separately in this article, when cellulosic ethanol conversion technologies become cost competitive, it is conceivable that cellulosic feedstocks could be integrated into existing corn ethanol plants, with appropriate modifications. Thus, an integrated system with both corn and cellulosic feedstocks (especially corn stover) could be evaluated. Such an integrated ethanol plant might have some unique advantages if one feedstock suffered from decreased production (e.g., the anticipated reduction in corn production in key Midwestern states in 2012 as a result of the severe drought).

In addition, cellulosic ethanol plants and their ethanol yields could be significantly different among different feedstocks. The source of the energy intensity data for converting a cellulosic feedstock to ethanol via a biochemical conversion process that we used in our WTW simulations was with the process of converting corn stover (Humbird *et al* 2011). We did not obtain separate conversion energy intensity data for other cellulosic feedstocks. In the future, we will examine the differences in both ethanol yield and co-produced electricity among different cellulosic feedstocks.

Co-produced electricity is another significant yet uncertain factor contributing to cellulosic ethanol's GHG benefits. Electricity yields in cellulosic ethanol plants, however, are highly uncertain. In fact, it is not entirely certain that cellulosic ethanol plants will install capital-intensive CHP equipment that would permit the export of electricity to the grid.

Considering the feedstock production phase, the significant difference in WTW results between switchgrass and miscanthus ethanol is caused mainly by the large difference in yield between the two crops (12 tonnes ha^{-1} for switchgrass versus 20 tonnes ha^{-1} for miscanthus). The high yield of miscanthus results in a significant increase in SOC content in simulations that use the CENTURY model (Kwon *et al* 2012), which is based on the common understanding that a high biomass yield can result in high below ground biomass accumulation. This implies that any cellulosic feedstock with a high yield, such as miscanthus, could sequester significant amounts of GHGs. Thus, instead of interpreting the results presented here as unique to switchgrass and miscanthus, we suggest that the results can indicate the differences between high-yield and low-yield dedicated energy crops.

For all bioethanol pathways, the strong dependence of GHG emission results on the N_2O conversion rate of N fertilizer suggests the need to continuously improve the efficiency with which N fertilizer is used in farm fields and the need to estimate that parameter more precisely. The needs are especially important with regard to nitrogen dynamics in sugarcane fields and cornfields.

In addition, the seasonal harvest of cellulosic feedstocks to serve the annual operation of cellulosic ethanol plants requires the long-time storage of those feedstocks. Feedstock loss during storage as well as during harvest and transportation is an active research topic. We will include cellulosic feedstock loss in our future WTW analysis of cellulosic ethanol pathways.

The WTW GHG emissions of petroleum gasoline are also subject to significant uncertainties. Some researchers estimated GHG emissions associated with indirect effects from petroleum use, such as those from military operations in the Middle East (Liska and Perrin 2010). Depending on the ways that GHG emissions from military operations are allocated, those emissions could range from 0.9 to 2.1 g MJ^{-1} of gasoline (Wang *et al* 2011a). Moreover, GHG emissions associated with oil recovery can vary considerably, depending on the type of recovery methods used, well depth, and flaring and venting of CH_4 emissions during recovery (Rosenfeld *et al* 2009, Brandt 2012).

5. Conclusions

Bioethanol is the biofuel that is produced and consumed the most globally. The US is the dominant producer of corn-based ethanol, and Brazil is the dominant producer of sugarcane-based ethanol. Advances in technology and the resulting improved productivity in corn and sugarcane farming and ethanol conversion, together with biofuel policies, have contributed to the significantly expanded production of both types of ethanol in the past 20 years. These advances and improvements have helped bioethanol achieve increased energy and GHG emission benefits when compared with those of petroleum gasoline.

We used an updated, upgraded version of the GREET model to estimate life-cycle energy consumption and GHG emissions for five bioethanol production pathways on a consistent basis. Even when we included highly debated LUC GHG emissions, when the feedstock was changed from corn to sugarcane and then to cellulosic biomass, bioethanol's reductions in energy use and GHG emissions, when compared with those of gasoline, increased significantly. Thus, in the long term, the cellulosic ethanol production options will offer the greatest energy and GHG emission benefits. Policies and research and development efforts are in place to promote such a long-term transition.

Acknowledgments

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NEWS & MEDIA

December 19, 2014

GROWTH ENERGY RESPONDS TO FLAWED UNIVERSITY OF MINNESOTA STUDY

Author: Growth Energy

WASHINGTON, DC — Following the recent report released by the University of Minnesota, "Life Cycle Air Quality Impacts Of Conventional And Alternative Light-Duty Transportation In the United States," which contains significant flaws in regards to their analysis of ethanol, Tom Buis, CEO of Growth Energy, released the following statement:

"Clearly this study was published with an agenda and without regard to the facts. It is misleading, inaccurate and runs counter to a large body of expert research.

"This report also fails to account for the numerous environmental benefits ethanol provides. According to Argonne National Laboratory, ethanol reduces greenhouse gas (GHG) emissions by an average of 34 percent compared to gasoline, even when the highly controversial and disputed theory on Indirect Land Use Change (ILUC) is factored into the modeling. However, the study by the University of Minnesota specifically excludes ILUC impacts, and Argonne has found that without ILUC included, ethanol reduces GHG emissions by 57 percent compared to gasoline.

"In fact, in 2013, the 13.2 billion gallons of ethanol blended into gasoline in the United States helped reduce GHG emissions by approximately 38 million metric tons, which is the equivalent of removing roughly 8 million automobiles from the road.

[redacted] "In addition, another critical component that was unsurprisingly left out of the University of Minnesota's report is that ethanol, with its high octane content, reduces the need to add toxic aromatics to gasoline to bolster octane and engine performance such as benzene and 1-3 butadiene that are known carcinogens. Additionally, ethanol plays a major role in reducing ultra-fine particulates in exhaust emissions that are linked to a large number of adverse health outcomes." [redacted]

# # #

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U Of M Report Contains Inaccurate And Misleading Information On Ethanol

Thursday, 18 December 2014 00:00

The recent report released by the University of Minnesota, "Life Cycle Air Quality Impacts Of Conventional And Alternative Light-Duty Transportation In the United States," contains several inaccuracies and misleading information.

In particular, its conclusion that corn-based **ethanol** contains more harmful pollutants than gasoline runs contrary to findings from the Argonne National Laboratory (which is a non-profit research laboratory operated by the University of Chicago for the U.S. Department of Energy), the U.S. EPA and the Energy Information Administration (EIA).

The authors of the report state that corn-based **ethanol** emits more **ozone** and particulate matter than gasoline. **Ozone** is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) while particulate matter is an air pollution term for a mixture of solid particles and liquid droplets in the air.

Both **ozone** and particulate matter can trigger health problems. While the U Of M's report states that these two pollutants increase with **ethanol** usage, data from the EPA suggests otherwise.

According to the EPA, the amount of **ozone** in the air has decreased 18 percent from 2000 to 2013. In the Upper Midwest, **ozone** levels have fallen 11 percent during the same time period.

Similarly, particulate matter has decreased 34 percent nationwide from 2000 to 2013. It is important to note that the drop in **ozone** and particulate matter coincide with the increase in **ethanol** blended gasoline which took off on a large scale after the implementation of the Renewable Fuel Standard in 2005.

Moreover, the Argonne National Laboratory's GREET (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) model – which was also used by the authors of the report – shows total urban life cycle emissions of VOC, NOx and particulate matter in a vehicle using E10 (gasoline that contains 10 percent **ethanol**) is lower than in a vehicle using gasoline which contains no **ethanol** .

If compared with a vehicle running on E85 (gasoline that contains 85 percent **ethanol**), GREET shows that the urban emission reductions are even more significant at 5 percent (VOC), 7.8 percent (NOx) and 20 percent (particulate matter).

Interestingly, the report did not address CO2 emissions which dominates greenhouse gas emissions. According to the EIA, a gallon of gasoline that does not contain **ethanol** produces 19.64 lbs of CO2. A gallon of **ethanol** , on the other hand, emits 12.72 lbs of CO2.

As such, E10 produces 18.95 lbs of CO2 while E85 emits 13.75 lbs of CO2. Thus, it is quite clear that using **ethanol** reduces the level of CO2 in the air.

In 2012, some 2.45 billion gallons of gasoline was consumed in Minnesota. If we assumed that all 2.45 billion gallons were E10, it would mean 766,571 metric tons of CO2 was prevented from being released into the air thanks to **ethanol** .

That, according the EPA's greenhouse gas equivalencies calculator, is the equivalent of removing 161,383 cars from the road for a year in Minnesota.

Considering the above, it is clear that **ethanol** is a much cleaner fuel than gasoline. Moreover, it is important to note that the authors of the study did not factor emissions from Canadian oil sands in their analysis of life cycle emissions from gasoline. This in itself casts more doubts on their findings as 70 percent of oil imported from Canada (which would include oil sands from Alberta) are brought into the Midwest.

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